The Engineer

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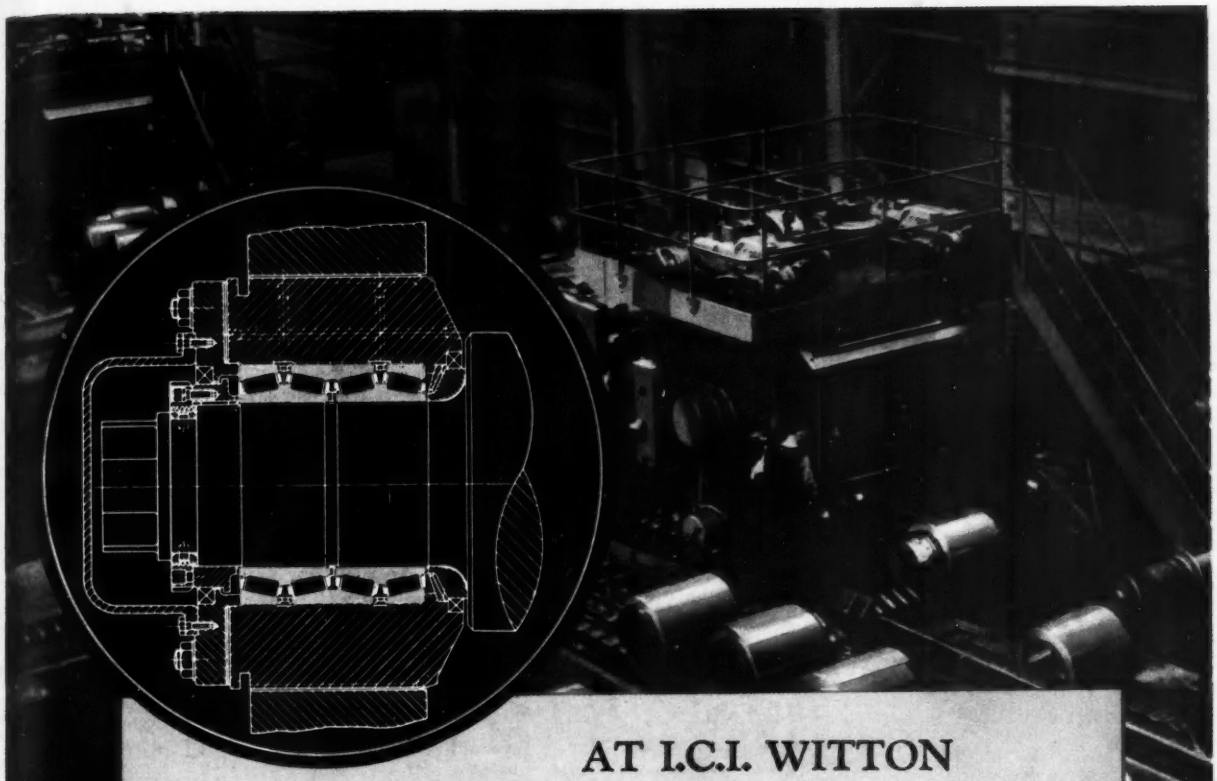

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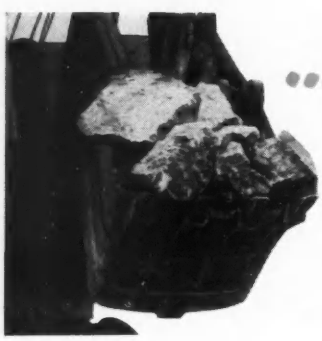

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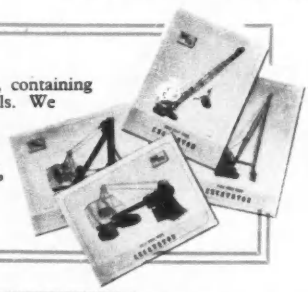

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THE ENGINEER

VOL. 201 No. 5219 FEBRUARY 3, 1956

CONTENTS

LEADING ARTICLES—
- Reports from Vehicle Testing Stations... 153
- How Many V-Bombers ? 154
- Printing Troubles 154

ARTICLES—
- Annual Review of Metropolitan Water Board's New Works. (Illus.) ... 170
- Anti-Submarine Aircraft. (Illus.) ... 175
- Combined Gear Hobbing and Shaving Machine. (Illus.) 172
- Copy Turning Lathe. (Illus.) 174
- Engravings of 1858. (Illus.) 165
- Expansion of the Imperial College ... 155
- Fume Scrubbing and Absorption Tower. (Illus.) 176
- James Clayton Prize 155
- Long Scale Moving Coil Temperature Indicator. (Illus.)... 176
- Marine Reduction Gearing. No. II. (Illus.) 156
- Maudslay Scholarships 155
- Modern Drawing-Office Lighting Installation. (Illus.)... 173
- Paper-Lapping and Test Equipment for Oil-Filled Cables. (Illus.) 169
- Potentialities of Railway Electrification at Standard Frequency. No. I ... 162
- Prefabricated Vehicle Bodies. (Illus.)... 176
- Radio Communication and Electronic Engineering Association 155
- Radioactive Ratemeter for Field Work. (Illus.) 175
- Steelwork of the New Passenger and Cargo Building at Southampton. (Illus.) 161
- Supersonic Blow-Down Tunnel. (Illus.) 164
- Vehicle Testing Station 164
- 40ft Tubular Plastic Structure for Radio Research. (Illus.)... 174
- 100 Years Ago 155

AMERICAN SECTION—
- International Atomic Exposition at Cleveland. No. III. (Illus.) ... 179

LETTERS AND LITERATURE 166
- LETTERS TO THE EDITOR—
  - A New Institution 166
  - Changing Characters of Institutions 166
  - Turbo-Blowers 167
- LITERATURE 167

NEWS AND NOTES—
- British Patent Specifications. (Illus.)... 183
- British Standards Institution 176
- Catalogues and Brochures 184
- Continental Engineering News. (Illus.) 177
- Forthcoming Engagements 184
- Industrial and Labour Notes 178
- Launches and Trial Trips 184
- Personal and Business 182

REPORTS FROM VEHICLE TESTING STATIONS

Despair sometimes grips us when we see the erroneous conclusions the uninitiated can draw from statistics. On Thursday of last week the Minister of Transport and Civil Aviation is reported to have remarked in a standing committee of the House of Commons which is considering the Road Traffic Bill that a report of the Ministry's vehicle testing station at Hendon revealed an " alarming" state of affairs, particularly in relation to older cars. But if the Minister had no more information than was printed in a document published by his Ministry and reprinted on page 164 of this issue, we beg leave to suggest that he was talking through his hat ! For, with the sole possible exception of a statistic that 78 per cent of cars have wrongly aimed headlamps—a figure that does not seem to us to reflect ordinary observation on the road—no more is revealed than that the condition of older cars falls, as might be expected, below perfection. That conclusion must seem rather obvious to an engineer but it is not particularly alarming. It is because the inspectors regard vehicles with certain defects as not " fully roadworthy " that the Minister has been alarmed by such a statistic as that 97 per cent of pre-1947 vehicles had such defects. But what is the standard of roadworthiness ? Full roadworthiness cannot be equated to perfection ; for any mechanical contrivance begins to fall to some degree out of adjustment the moment it begins to be used. How much play is permissible in a steering linkage before a vehicle becomes not fully roadworthy ? How low must braking efficiency fall ? How inaccurate must be the setting of headlamp beams ? That in assessing such matters the factor of human opinion creeps in can be seen by comparing the conclusions of the Hendon station with those of the Slough centre which operated for one month last July. Where an item of equipment either works or fails to work, as with traffic indicators, the two stations report substantially the same percentage of cars with the defect, 15 per cent and 15·7 per cent, respectively. But for other defects the percentages are widely at variance ; headlights 78 per cent and 35 per cent ; steering 30 per cent and 47 per cent ; brakes 26 per cent and 44 per cent. There is no consistency. The same standards cannot have been applied at the two stations to determine roadworthiness.

Even of post-1953 cars as many as 77 per cent, according to the Hendon station, had defects making them not fully roadworthy. The very height of that percentage makes the reader chary of accepting it as uncritically as the Minister has done. For our part we suspect that the standard of roadworthiness has been based solely on the state of the vehicle, allowing nothing either for its performance characteristics or the subjective reactions of a driver to its defects. That performance characteristics are important is demonstrated by the calculation that a vehicle capable of a maximum speed of 40 m.p.h. is as safe at that speed, judged by braking distance, with a brake efficiency only half as high as that of a car travelling at 60 m.p.h. And that the subjective reactions of a driver are important is obvious from the fact that drivers are neither murderously nor suicidally inclined. It is highly unlikely, for example, that any driver, knowing the brakes are inefficient, will drive in any given circumstances with no more caution than would be consistent with excellent brakes. A driver, in short, drives a vehicle at such a speed and in such a way as he believes will be safe taking into account any known defect of the vehicle. He may, indeed, misjudge his safety. But the presence of a defect does not necessarily make the vehicle unroadworthy in his hands; and he may as easily misjudge his safety even if the vehicle is in perfect order. Only of certain defects can it be definitely said that they make a vehicle not fully roadworthy. There are, for instance, those which lead to unpredictable behaviour. Slackness at the kingpins may, for example, make a vehicle swerve unpredictably upon a brake application. But, it is to be observed, it is not a necessary consequence of any defined degree of slackness. How great the slackness can be depends on the design of the vehicle. Unequal braking torque at the wheels may produce a similar result. But the results revealed by a testing machine cannot in that respect be regarded as representative of road behaviour because

there is no transference of load between front and rear axles and consequently no stressing and deflection of the frame and mechanism. Only tests on the road can reveal whether behaviour is unpredictable or not. A much more dangerous defect which a testing station may be able to discover is that which is not known by a driver, such as the imminent failure of a pipe or connection in a hydraulic brake system, or the cracking of a spring. Such imminent defects really do make a vehicle not fully roadworthy.

The Minister is reported, apparently upon the basis of the situation revealed by the Hendon station, to have decided to include a scheme for compulsory vehicle testing in the new Road Traffic Bill. It does seem to us, however, that if testing stations come into being more satisfactory standards of "roadworthiness" than those applied at Hendon will need to be worked out. To give a satisfactory result those standards will need to be varied to accord with the make and performance of the vehicles concerned; no standard can be satisfactory that is not based in part upon a road test; and a distinction needs to be drawn between defects that lead to unpredictable behaviour and those that do not. To reject a vehicle as unroadworthy because, for instance, the play at the steering wheel exceeded some standard figure, without determining whether it really affected its behaviour on the road would be ridiculous.

HOW MANY V-BOMBERS?

The Defence White Paper, shortly to be presented to Parliament, is unlikely to initiate any drastic change in the Government's defence policy announced a year ago. Unless taxation is to be increased, there can be no substantial increase in the defence budget of £1500 million to £1600 million of the past few years, if the welfare state is to be maintained. Apart, moreover, from the rising cost of new weapons and equipment, provision has to be made in the forthcoming year for considerably higher pay for the Regular Forces. It is thus essential, if the country is to have the most effective defence possible within our limited resources, that the British people should understand what is being done to defend this country and not just "leave it to the Government." The hydrogen bomb seems to have engendered a feeling of apathy. "Even a dictator will not want to go to war nowadays and there is no use thinking about it." The Soviet rulers have good reason to encourage this outlook among the Western nations. The test of a super-hydrogen bomb in Russia so soon after the failure of the Geneva Conference was quite obviously intended to emphasise at that moment that she, too, is strong in nuclear power. The Kremlin well knows that war against the West would bring nothing but disaster to both sides, but the Russians want to make quite certain that this is fully realised by the Western nations. Meanwhile, under the shield of the hydrogen bomb, they hope to pursue with reasonable safety their own aims, many of which are opposed to those of the West. Since the build-up of the United States Strategic Air Force after the war, and still more since General Gruenther announced N.A.T.O.'s plans to use atomic weapons to resist aggression, it has become increasingly evident that Russia has no intention of committing a deliberate act of aggression on the Continent. But she has built up an active army of 175 divisions and 25,000 tanks, an air force of 20,000 aircraft and a navy which in a year or two will consist of thirty powerful cruisers, 500 submarines and 4000 naval aircraft to ensure that the economy of the western nations is strained to the utmost in maintaining conventional forces to counter them.

The real danger of a major war results from the existence of these conventional forces—their use on the one hand by the United Nations to counter aggression in the Middle or Far East, and on the other hand by the Russians to support, either directly or indirectly, the aggressor. Would the United States again be prepared to suffer thousands of casualties if they could be prevented by the use of atomic weapons? There can be no borderline between atomic and thermo-nuclear missiles and a minor conflict of this nature, with neither side willing to give way, might well develop into a full-scale major war. Britain is, therefore, building up a strong force of "V"-bombers, each costing about £500,000, to strengthen the deterrent already provided by the United States Strategic Air Force. The adequacy of this United States force as a deterrent is not in question. It is of massive strength and power and is being still further strengthened by the replacement of earlier bombers with "B-52s." None the less, the British Government considers it essential that we should have our own strategic air force if we are to have any say in the framing of N.A.T.O.'s policy and strategy. This is all to the good, provided the force is not so large that we cannot concurrently build up our guided missile defences and ensure the safety of our sea communications. Substantial progress has already been made with the production of bombers—which is receiving the utmost priority—but there is as yet no mention of the issue of air-to-air guided missiles for our naval and air force fighters nor of a production order for ground-to-air guided missiles. It would be Russia's first object to eliminate Britain as an operational base and there seems little purpose in having large numbers of bombers if their airfields are to be left undefended.

The United States, which keeps a substantial number of bombers at two hours' notice, is now erecting a wide network of ground-to-air guided missile batteries and has already armed her interceptor fighters with air-to-air missiles. She is also building a fleet of 60,000-ton carriers—Congress approval is being asked for a sixth vessel of this kind—to reinforce her air force bombers, or to replace them in the event of their airfields being out of action. These huge vessels are intended to operate bombers which have a longer range than the "Canberra." British Defence Chiefs do not believe that strategic bombing is the function of the Royal Navy. The Royal Navy carriers are of medium size, though their strike aircraft would be of the utmost value in bombing enemy submarine harbours and war potential installations in coastal areas. But the Navy urgently needs more carriers and more vessels of the cruiser type with modern anti-aircraft protection (known as guided missile ships) to carry out its primary function of keeping open the sea routes. How is it possible for this country with her limited resources to build an adequate number of these vessels and to provide effective guided missile defences for the homeland, if we are at the same time to build large numbers of bombers each costing £500,000? The First Lord and other Government spokesmen emphasise that the tasks of the Royal Navy must be considered in relation to the assistance to be given by the navies of other N.A.T.O. powers. It is a yardstick that might legitimately be used to fix the size of the British Strategic Air Force. But a country which depends for her survival on her sea communications should not, in our view, be indebted to other nations for its safety.

PRINTING TROUBLES

This issue is noticeably thinner than those we are accustomed to publish. There is less editorial than we need adequately to cover the week's events and there are many fewer advertisement pages than there ought to be. Some readers may receive their copies a little late. But we cannot help it. The fault is not ours. A dispute in the printing trade has resulted in members of certain printing unions "working to rule" with the consequence that the whole printing process has been slowed down and less than usual can be done in any given period. The indications, as we write, are that the situation is likely rather to deteriorate than improve. Looking ahead, indeed, we are already wondering whether next week's issue will appear at all. We hope it will. But a complete stoppage at the printers is a possibility. Our apologies are due both to readers and advertisers. We promise that we shall revert to normal as soon as the printing trade permits.

A Seven Day Journal

The James Clayton Prize

THE Institution of Mechanical Engineers has announced the award of the 1955 James Clayton prize to Dr. E. A. Watson. Dr. Watson receives the prize for his notable work in automobile engineering and for his outstanding contributions over the last fifteen years to the progress of the aircraft gas turbine, particularly in the fields of combustion and fuel control, which formed the subject of his James Clayton lecture in December last. Extracts from this lecture were printed in THE ENGINEER of December 23 and 30, 1955. Dr. Watson was educated at King Edward's High School, Birmingham, and at Birmingham University, where he obtained an honours degree in mechanical and electrical engineering in 1907. In the same year he was awarded an 1851 Research Exhibition and continued his studies at Liverpool University, being engaged in research on dielectric strength of air and losses from transmission lines. Dr. Watson is now a director and the chief engineer of Joseph Lucas, Ltd., and during the second world war was responsible for the activities of the firm and its associates covering research on combustion problems, the development of combustion chambers and of fuel supply and control equipment. Dr. Watson was elected to membership of the Institution of Automobile Engineers in 1926, became a member of its council in 1940, and continued as a member of the automobile division council following the amalgamation with the Institution of Mechanical Engineers in 1947. In that year he presented a paper to the Institution of Mechanical Engineers, entitled "Fuel Systems for the Aero-Gas Turbine," for which he received the Dugald Clerk prize.

Radio Communication and Electronic Engineering Association

THE radio manufacturing industry is estimated to produce an annual output of more than £220 million, one-third of which is believed to be accounted for by radio communication and electronic engineering equipment. This part of the radio industry is represented by the Radio Communication and Electronic Engineering Association (R.C.E.E.A.), members of which produce civil and military equipment for long- and short-range communication by land, sea or air, broadcasting transmitters for radio and television, radio and radar navigational aids, electronic instruments, computers and electronic equipment for industry. In 1955 direct exports (excluding equipment installed in ships, aircraft or machinery sold abroad) reached a record total of £13,000,000. In all, eleven microwave radio links have now been supplied for television networks in Switzerland and Italy and for the "Eurovision" international exchange of programmes. Exports associated with television also include twelve flying-spot scanners for Italy, Switzerland and Poland. At home the industry supplied the B.B.C. with television transmitters for Pontop Pike, Crystal Palace and Meldrum and has delivered seventeen cameras and two pairs of transmitters for the B.B.C.'s proposed alternative programme. During the year narrow beam, super-high-frequency microwave radio links were supplied for service between Dundee and Aberdeen as a permanent extension to the G.P.O.'s television network and to Canada for the 525-line television relays between Montreal and Quebec and between Toronto and London, Ontario. In sound broadcasting the B.B.C. began to implement its plan to provide v.h.f./f.m. coverage over the whole country in the knowledge that congestion in the medium-wave band limits progress in that direction; the stations at Wrotham, Wenvoe and Pontop Pike came into service during the year. An important extension was completed at the G.P.O. Rugby radio station, where twenty-eight high-power transmitters were installed for long-distance short-wave communications. A number of single-channel v.h.f. links, eighty of which are on order, were shipped to Sarawak, North Borneo and Brunei, where difficulties of terrain make the laying of telephone lines impracticable. At London Airport a crystal-controlled radar, the first of its kind in the world, went into service. There the radar equipment also includes a "Q band" set, which gives a visual plan of the airfield, showing aircraft on the runways and taxiways. An increasing proportion of the R.C.E.E. Association's work is concerned with electronic engineering. Electronic equipment is being developed for controlling machine tools, such as jig borers and three-dimensional contouring machines, and computers are being used to control the operation of machine tools. One industrial application of television is exemplified at Calder Hall power station, where television cameras are being installed inside the reactors, the operation of which can thereby be observed from a distance.

100 Years Ago
The Engineer
(FEBRUARY 1, 1856)

INSTITUTION OF MECHANICAL ENGINEERS

"The proceedings at the Annual Meeting of the Institution of Mechanical Engineers, held at Birmingham on Wednesday evening, were of an interesting character. Mr. Fairbairn presided. . . . The position of the Institution, financially speaking, was stated to be in a satisfactory state, but at the same time an addition of members would be most acceptable. Efforts are being made, also, to establish a library and museum. . . .

"Before parting with the subject, we cannot but express our regret that greater publicity is not given to the proceedings of the society. . . . If it be necessary or convenient to delay the appearance of the detailed reports, could not a copious abstract be supplied immediately after the meetings? We find that such abstracts are given to the four Birmingham journals, and to no others, a week or ten days after the meeting. Now, the Institution of Mechanical Engineers is not a mere local establishment, it is a national institution; it is one, the members of which are scattered all over the kingdom, and the proceedings of which are as interesting to the practical engineer in Aberdeen or Belfast as to his brother in Hayle or Dover. Why, then, are the reports to be confined to the Birmingham journals? . . . We do not speak for ourselves alone; but we insist that it should be the first duty of the Institution to supply a report of their transactions to every scientific and mechanical journal in the kingdom; and until that is done, and the importance and value of an association such as the one which, for general convenience, has chosen 81, Newhall-street, Birmingham, as its meeting house, are by these means brought fully under public and professional notice, it will never occupy the position to which it is entitled, or be enabled to exercise the weight and authority which it might and ought to possess."

Maudslay Scholarships

WITH the aid of funds provided by the trustees of the Maudslay Scholarship Foundation and administered jointly by the Junior Institution of Engineers and the Maudslay Society, scholarships and prizes are offered to young engineers for the purpose of assisting them in their technical education and practical training. The councils of the Junior Institution and the Maudslay Society have announced the rules for the award of the Maudslay scholarships and prizes for 1956. These rules state that the value of any one scholarship will not exceed a total sum of £400. This may be awarded as a single sum or in annual instalments over not more than four years. Applicants for the Maudslay scholarship who are unsuccessful may be awarded Maudslay prizes of a maximum value of £50. Candidates must not be more than twenty-seven years of age (i.e. must not have passed their twenty-eighth birthday on March 31, 1956), must be engineers or training to be engineers, and must have attained the same standard of education or engineering training as is required for membership of the Institution in the appropriate grade. Fuller information can be obtained from the Secretary of the Junior Institution of Engineers, Pepys House, 14, Rochester Row, London, S.W.1.

Expansion of the Imperial College

IN a reply to a question in the House of Lords on January 25th, the Government announced its decisions on the doubling of the Imperial College of Science and Technology; the full expansion, planned in 1953, will go forward without delay. Considerable developments have already occurred on the central South Kensington site and the student population at the College has risen by 25 per cent. Further progress has been difficult because of the occupation of parts of the site by various other bodies, and in particular by the Imperial Institute. The College was asked by the Government to provide for 3000 students. To meet this requirement plans have been prepared which provide a total floor space of 1,800,000 square feet, of which nearly 1,600,000 square feet is on the central site. The College and its architects aimed at a bold and unified plan for the area, providing for very large new buildings for civil, mechanical and electrical engineering. This was in addition to the new building for aeronautical and chemical engineering, already well on its way to completion. The plan included developments on the central site for refectories, libraries common rooms and so on. The site contained, among a variety of structures, the prominent "Colcutt" building, which fronts Imperial Institute Road. It runs from east to west on the southern end of the site. In spite of its impressive bulk, its interior is inconvenient, the College authorities consider, and it provides singularly little useful floor space; its demolition is therefore part of the plan.

Marine Reduction Gearing

By A. W. DAVIS, B.Sc.

No. II—(*Continued from page 123, January 27th*)

At the Institution of Mechanical Engineers on January 20th, Mr. A. W. Davis, who is deputy managing director, Fairfield Shipbuilding and Engineering Company, Ltd., Glasgow, presented the twenty-eighth Thomas Lowe Gray Lecture. We reprint here the greater part of the Lecture exclusive of appendices that accompanied it.

Considerations Arising from Pinion Distortion and Malalignment Modified by Tooth Deflection

(The symbols used in this and following sections are listed in a footnote; tooth proportions are as given in Fig. 8.)

It has been customary to design gears allowing for a maximum circumferential tooth separation of 0·00075in due to combined bending and torsion of the pinion on the assumption of a uniformly distributed load along the teeth. In fact, the teeth deflect differentially along their length in sympathy with an altered distribution of load brought about by the distortion. The problem is capable of elaborate treatment, but by the approach described in Appendix III it is shown that approximately the maximum as compared with the average tooth load for double helical pinions is given by

$$\frac{P_m}{P}=1+\frac{\sec\psi_N}{16\delta_T\times10^6}\left(\frac{W+\frac{1}{2}G-6s}{D+(2m-1)}\right)^{2\cdot5}_s$$

or in the case of a double helical pinion engaging a pair of divided train gears at 180 deg. spacing

$$\frac{P_m}{P}=1+\frac{1}{19\cdot5\delta_T\times10^6}\left(\frac{W-6s}{D+(2m-1)}\right)^2_s$$

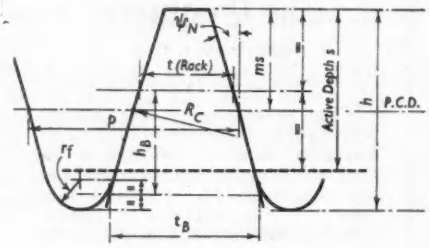
Values of δ_T, the tooth flexibility factor (in terms of inches tangential deflection in a circumferential plane per pound of tangential load per axial inch of gear face), have been determined from repeated full-size deflection tests on equipment illustrated by Fig. 9(*a*) and (*b*), and by a method described in an appendix to the paper [not here printed], the results of which are graphed in terms of $\delta_T\times10^6/Q$ on Fig. 10, where

$$Q=\frac{h_B/t}{1\cdot25s/p}.$$

The values bear additive quantities representing Hertzian compression derived from calculations by Niemann (1949).

For ease of comparison values of $\delta_T\times10^6$ for the tooth forms in more common use are given by Table I. It may be noted that a deep form of tooth does not show up as more flexible than a shallower tooth of the same flank angle, because actual load per unit length along the teeth is reduced on account of the longer zone of contact by the same factor as the flexibility is increased, so that no further advantage accrues to a deep tooth so far as flexibility is concerned.

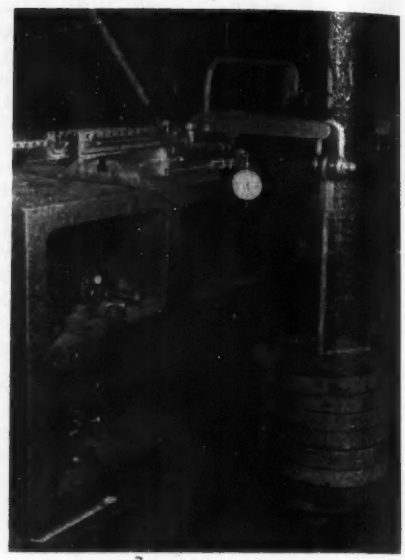
In an appendix [not reprinted] it is also shown, as a derivation from the above equations, that with a double-helical pinion



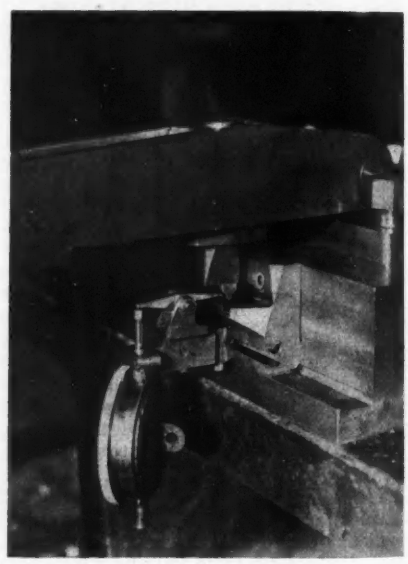
SECTION NORMAL TO TOOTH.

p_f Pitch fitted (if differing from desirable or theoretical pitch).
σ Helical angle. ψ_P Pressure angle in transverse plane.
z Tangential length of contact zone in transverse plane.

Fig. 8—Symbols for tooth dimensions



a—Arrangement.



b—Detail

Fig. 9—Equipment for measuring tooth flexibility

Symbols

Symbol: Having application in final conclusions	Symbol: Having permanent application in detail	Symbol: Used only for convenience of expression	Meaning (lb-in units unless otherwise stated)
Gear proportions :			
		B	Breadth of one helix
D			Pinion P.C.D.
D_e			D [gear ratio/(1 + gear ratio)]
G			Gap between helices
		I	Moment of inertia of pinion section
		L	½ (effective length between pinion bearing centres)
W			$2\times B$
W'			Theoretical optimum value of W for minimum load concentration
Bearing dimensions :			
D_b			Journal diameter
d			Diametral bearing clearance in $^1/_{1000}$in
Loads, forces and pressures :			
		F	Reaction on one pinion bearing
P			Average tangential load per inch gear face (based on $(W-2)$ inches)
		P_b	Bearing pressure on projected area
		P_f	Pressure in oil film between teeth
	P_m		Maximum value of P
		P_N	P converted to force normal to tooth
Stresses :			
	S_H		Hertzian stress (conventional)
	S_P		Hertzian stress (see Appendix XII)
	S_R		Root bending stress
	U		U.T.S. of pinion material, tons per square inch
Speeds :			
N			Pinion speed, r.p.m.
		V_s	Tooth sliding speed (relative)
		V_R	Tooth rolling speed (relative)
Criterion numbers and factors :			
C'			Gear loading C factor, ′ indicates incorporation of material constants
C_D	c_d		Pinion distortion multiplying factor (about 1·0 for well-designed gear)
		C_F, k_F	Criterion of Martin oil film pressure
		C_H, k_H	Criterion of Hertzian stress
C_P', k_P	k_P''		Criteria of pitting, root stress, and scuffing respectively
C_R', k_R	k_R''		$C_P=K.k_P$, &c. and $C_P=K.k_P'$, &c. } ″ indicates use in particular comparison
C_S', k_S	k_S''	c_s	
C_{MP}			Material constants representing effect on resistance to pitting, root fatigue, and
C_{MR}			scuffing respectively for materials other than current standard materials
C_{MS}			
K			Conventional K factor P/D_e
Common symbols used in mechanics :			
		E	Modulus of elasticity
		e	2·718
		λ	Poisson's ratio
		μ	Viscosity (relative)
Sundry functions and coefficients :			
		A	Local significance (Appendix III)
		a	Local significance (Appendix III)
		b	Local significance (Appendix III)
	δ_{BN}, δ_{BT}		Normal and tangential deflections of a pair of teeth due to bending and shear
	δ_{HN}, δ_{HT}		Normal and tangential deflections of a pair of teeth due to Hertzian compression
δ_T			Combined tangential tooth deflection, inches per pound per inch load
		f	Thickness of oil film between teeth
		H	Local significance (Appendix II)
		J_s	Local significance (Appendix IV)
		l/l	Effective length of loaded oil film between teeth
Q			Tooth proportion factor for estimation of δ_T
		t_A	Local significance (Appendix III)
		x	Local significance (Appendix III)
	X_f		Root fillet stress raiser
	X_β		Stress modifier for helical teeth
	X_σ^δ		Function of helical angle that affects root stress
	Y		Function of tooth form (equal to 1·0 for consistent series)
	y		Function of angularity of line of contact as it affects tooth deflection
		y_A	Local significance (Appendix III)

Tooth proportions and angles, see Fig. 8

in single engagement having a central gap of about 3in, the optimum ratio of face width to pinion diameter to give the least localised tooth load as based on this theory is given by

$$\frac{W'-2}{D}=2\cdot6\left[1+(2m-1)\frac{s}{D}\right]\left(\frac{\delta_T\times10^6}{\sec\psi_N}\right)^{1/2\cdot5}$$

and for double engagement at 180 deg. spacing

$$\frac{W'-2}{D}=4\cdot4\left[1+(2m-1)\frac{s}{D}\right](\delta_T\times10^6)^{1/2}.$$

Appropriate to these particular ratios P_m/P has the values 1·67 and 2·0 respectively.

In considering the theoretical value of W'/D it is important to recognise that :

(i) The conditions determining this turning point of low loading are extremely sensitive to changes in tooth alignment that might be brought about (*a*) deliberately by relief of the tooth flanks or (*b*) accidentally by errors of bearings, gearcase, distortion or helical angle ;

(ii) The characteristic is not sharply defined and some deviation from whatever may be the theoretical value is not important ; and

(iii) Whatever theory is employed, the nature of the problem demands resort to assumptions and approximations and no means is possible whereby the resulting degree of error can be even approximately measured.

TABLE I—$\delta_T\times10^6$ *and Y Values for Particular Tooth Forms*

	Tooth form		$\delta_T\times10^6$ Helical angle, deg.					Bending stress factor, *Y*
	ψ_N, deg.	s/p	0	10	20	30	40	
a	14½	$2/\pi$	0·25	0·30	0·375	0·48	0·64	0·79
b	20	$2/\pi$	0·185	0·225	0·275	0·315	0·38	0·915
c	22½	$2/\pi$	0·22	0·265	0·33	0·35	0·38	1·0
d	16	$2/\pi\times1\cdot2$	0·245	0·295	0·36	0·445	0·565	1·0
e	14½	$2/\pi\times1\cdot44$	0·215	0·255	0·32	0·415	0·55	1·0

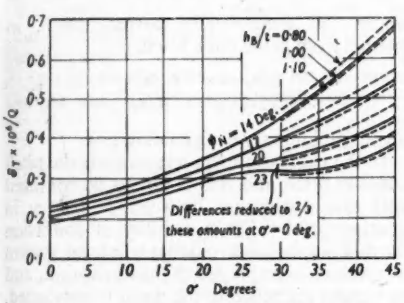


Fig. 10—Tooth flexibility chart

These hard facts must not, however, be allowed to obscure the importance of having a reasonably sound theoretical basis for W'/D as an accepted nucleus about which several utterly vital influences may be crystallised, influences which have sometimes evaded proper attention, with dire consequences.

The results of the theory presented here pass the one possible test that they indicate W'/D values substantially in accordance with current practice—actually slightly low, but with a margin, the existence of which is supported by a consideration that follows in the course of a few paragraphs.

First, however, the effect of gross alignment errors requires consideration and repeated reference follows to Fig. 11, which illustrates some general principles with particular examples. With a centre distance between effective bearing supports of 40in, a journal alignment error of about 0·007in in the direction of the load line at the untorqued end of a double-helical pinion in single engagement will, with tooth flexibility $\delta_T\times10^6$ of 0·4, give $P_m/P\doteqdot4$. If the pinion having diameter 17in is designed in accordance with the above theory to have a minimum P_m/P when in true alignment, it will have face width of 32in and the variation of P_m/P with alignment is shown by the curve marked *A*, being 1·67 in true alignment.

If the tooth flanks of this same pinion are now relieved 0·00025in at the torqued end, it can be shown that

$\frac{P_m}{P}-1$ is reduced by the factor $1+\frac{250}{P\cos\sigma\,.\,\delta_T\times10^6}$

and if $P=1000$, P_m/P is reduced to 1·48, the condition being illustrated by curve *C* on the same diagram. This would enable the gear to carry 14 per cent greater load without increasing the maximum loading in true alignment. But a journal alignment error of 0·007in would still give approximately the same P_m/P as the unrelieved pinion *A*, and under these abnormal but not infrequently possible conditions gear *C* is not suitable for carrying any heavier load than gear *A*.

The optimum face width when such relief is carried out increases in the ratio

$$\left(1+\frac{250}{P\cos\sigma\,.\,\delta_T\times10^6}\right)^{1/2\cdot5}$$

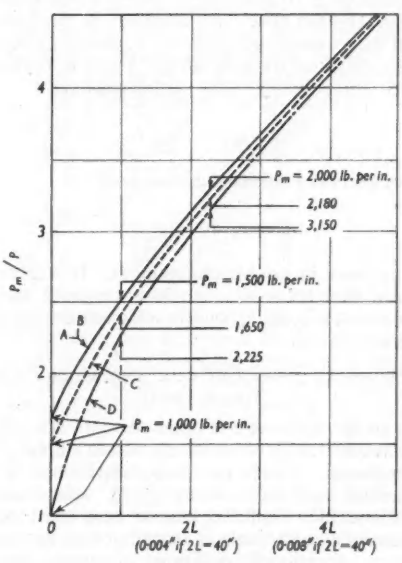
to about 40in in this example, the P_m/P at true alignment reverting to 1·67. Such a gear, referred to as *B*, would carry 26 per cent more load than *A* for the same maximum tooth pressure, and as its characteristic with increasing malalignment is almost identical to gear *A*, the curves representing the two gears are virtually coincident. The bearing-supporting centres would now increase to 50in and it would take a proportionately greater journal displacement of about 0·0085in to make P_m/P equal to about 4. Thus under all conditions gear *B* is suitable to carry 26 per cent greater load than gear *A*. Gears bearing the particular combined characteristic as described here for gear *B* are now being referred to as "broad relieved." The relief should be approximately in the proportion to *P* shown above and clearly becomes too small for practical consideration when *P* is much less than 1,000. A relief of 0·00025in has the merit of corresponding to a definite witness when checking gear marking in the best practice.

This comparison justifies careful reflection. Part of its import is seen with greater effect in referring to the "corrected" gear (Joughin, 1951), of which gear *D* on Fig. 11 is an example, that is, a gear of the type which has been considered advantageous to meet severe conditions of loading, and in which the helical angle of the pinion has been adjusted along the face width so as to conform with the reflected deflection of the pinion under full load when evenly loaded along its length so that $P_m/P=1$. Under true alignment gear *D*, with face width 32in, would carry 67 per cent more load than gear *A*, but with 0·007in journal alignment error P_m/P again approximates to 4 and the gear is not suitable for any greater load than *A*. Thus the conception of a "corrected" gear fails in that such a gear is extremely sensitive to alignment errors.

From the viewpoint of gear-load assessment the significant finding of this investigation is that a gear having P_m/P less than the optimum value (1·67 on basis presented) is not suitable for advantage to be taken of the fact by increasing load. One conclusion to be drawn from this would be that the existing practice of ignoring P_m/P in defining gear loading is fully supported. But this does have the serious disadvantages that :

(*a*) There is no recognised method of assessing the effect of gear loading when P_m/P is more than the optimum value. Perhaps a lack of information regarding permissible limits of Hertzian stress and root stress has obscured the significance of the omission. But more is known of the incidence of scuffing, and a subsequent section illustrates the vital use of the P_m/P factor.

(*b*) There is no recognisable warning sign to prevent serious mistakes being made in taking seemingly innocent advantage of low P_m/P values to overload malaligned gears.



A, uncorrected gear.
W=32in (theoretical optimum).
Relative horsepower=100 as basis of comparison.

B, gear with helix end relieved 0·00025in.
W=40in (theoretical optimum).
Relative horsepower=126 for same maximum load under any similar condition of alignment.

C, gear with helix end relieved 0·00025in.
W retained at 32in.
Relative horsepower=114 for same maximum load only when in alignment.

D, corrected gear.
If *W*=32in, relative h.p.=167 } for same maximum load only
If *W*=40in, relative h.p.=210 } when in alignment.
2*L*=Effective length between pinion bearing centres.

Fig. 11—Tooth load concentration

The view is submitted that P_m/P should be incorporated as a factor in all formulæ for the assessment of gear loading but that by the method of calculation shown here, it should never be less than 1·67 even although by calculation the figuring shows a lesser value. To simplify procedure the distortion coefficient c_d should be employed in lieu of

$$P_m/P \text{ and should equal } \frac{1}{1\cdot67}\cdot\frac{P_m}{P} \text{ or } \frac{3}{5}\frac{P_m}{P}.$$

Thus c_d could never be entered as less than 1·0 and for the bulk of well-designed gears c_d would be 1·0. If for any reason a slender gear were required, due regard would automatically be given to its shortcomings in determining permissible loading.

In a divided train gear, however, as the optimum face-width ratio occurs when $P_m/P=2\cdot0$, c_d must be taken as $\frac{1}{2}P_m/P$.

None of the particulars given above is applicable without modification to the older type pinions with centre bearings.

It would be unfitting to close this section

where such urgent reference has been made to malalignment, without a word on the correcting influence of slew of the journals in the bearings due to differential loading of the oil film. It has often been hopefully imagined that such a process would occur to a useful degree in compensating for shortcomings in alignment, but doubts as to the useful proportion of the slew to the error are confirmed from recent measurements made by Pametrada on the attitude of journals in bearings, and from which it can be estimated, as shown in Appendix IV [not reproduced here] that, when the bearing load is maldistributed ±50 per cent, the total slew correction is

$$\frac{N \cdot D_b \cdot d}{10{,}000 P_b}$$

thousandths of an inch ; from this it can be calculated that slew will not usually correct more than 10 per cent of the malalignment. To take the effect into account on the basis of the assumptions made in Appendix IV, C_D is substituted for c_d in all the above remarks, the relationship being approximately

$$C_D = c_d\left[1-\frac{c_d-1}{75}D\right]$$

for gears in single engagement and

$$C_D = c_d\left[1-\frac{c_d-1}{38}D\right]$$

for gears in double engagement. It will be seen that the correction is quite small and for most practical purposes with well-designed gears $C_D = c_d$.

Tooth Loading Criteria and Choice of Tooth Form

In its approach to gear design, B.S.436 takes the reader immediately into an empirical treatment based on long experience in general operation, focusing on wear and fatigue life. But the marine gear must be provided with such a margin of safety to meet exceptional conditions of storm, that these factors have no primary application, and the best treatment for design is therefore by recourse to more fundamental principles rather than general conventional formulæ.

Appendices [not reprinted] show the development of three criterion coefficients C_P, C_R and C_S relating respectively to tooth failure by pitting, root stress and scuffing. The numerical coefficients have been chosen so that when the undernoted conditions apply, a thoroughly sound merchant gear design is, in the author's view, achieved when none of the criterion numbers exceeds 100. This is conditional upon the use of what have been for many years regarded as standard materials (Dorey, 1942), viz. 0·3 per cent carbon steel 31–35 tons ultimate tensile strength (U.T.S.) for the rims and 3·0 per cent nickel steel, oil quenched to 40–45 tons U.T.S. for the pinions, lubricated with a standard undoped oil and having normal high accuracy tooth finish by, say, shaving, aligned according to proper shop and fitting-out practice and submitted to conditions of transmission which do not involve exceptional cyclic irregularity (Yates, 1955).

With the numerical coefficients chosen, it is believed that under normal conditions of service at sea there is a factor of safety of about 1·5 on tooth loading against pitting fatigue, and 4·0 against bending fatigue, although as records are based on gears of older construction the safety margin is probably now greater. Against scuffing the factor of safety is about 1·25 under full-power trial conditions with proper tooth profiles, but this rapidly and indefinitely increases with improvement of surface and profile and by work hardening under running conditions. The reasons for the variation in the respective factors of safety are obvious, but it is to be observed that a gear which scuffs on trial and is subsequently "dressed up," or a gear which has excessive tip relief in an effort to avoid such trouble, carries a lesser margin of safety against subsequent pitting fatigue by reason of the lesser useful tooth surface that remains.

The expressions for the criterion numbers are :

$$C_P = K \cdot k_P \; ; \; C_R = K \cdot k_R \; ; \text{ and } C_S = K \cdot k_S$$

where $K = P/D_e$ conventionally and k_P, k_R, and k_S are respectively given by expressions in Appendices VII, VIII and IX [omitted].

General use may be made of these expressions for the analysis of existing designs, and they also form the basis upon which to examine the character of patterns produced by altering variables with the object of defining the most suitable proportions of teeth in terms of variables that are relevant.

The cardinal points emerging from this analysis are :

(1) Referring to Fig. 12, tooth forms *e*, *d*, and *c* form a series meeting all requirements,

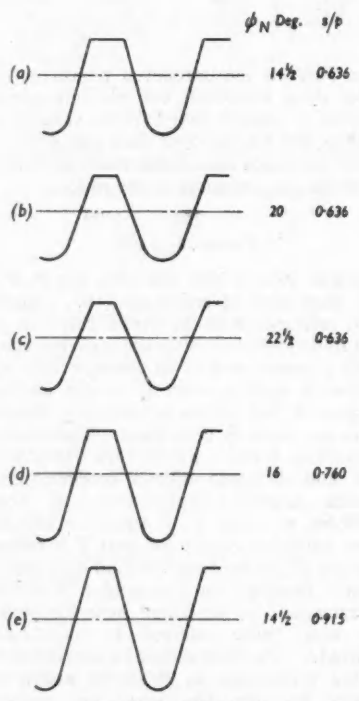


Fig. 12—Tooth forms

having certain consistent characteristics. From the point of view of the master expression representing surface pressure, the forms are to be preferred in the above order.

(2) Form *e* should not be used for a pitch less than $^7/_{10}$in.

(3) The liability to scuffing with these tooth forms is in the reverse order to that preferred for surface pressure and this entails an overriding restriction which will follow as an outcome of this analysis.

(4) Existing practice is confirmed in that tooth forms *e* and *d* should be associated with a helical angle of 30 deg. For a flank angle of 22½ deg. the helical angle for minimum root stress should be 40 deg., but for the sake of consistency in the present examination it is temporarily assumed to be associated with a 20 deg. helical angle.

(5) The proportion of pinion addendum to active depth should only be increased above 0·5 if a slight increase enables a tooth of smaller pitch to be used. The particular case of an all-addendum tooth is referred to in an appendix [omitted].

Before this information can be channelled to lead to any broad conclusion it is necessary to establish a suitable expression for loading, and this will be in the form of a C factor which will be developed from the basic relationship

$$C = C_P\left[\frac{C_R}{C_P} \text{ or } \frac{C_S}{C_P} \text{ or } 1{\cdot}00\right] \text{ whichever is greatest}$$

$$= K \cdot k_P\left[\frac{k_R}{k_P} \text{ or } \frac{k_S}{k_P} \text{ or } 1{\cdot}00\right] \text{ whichever is greatest}$$

In this regard, C_P is in the nature of a master, while C_R and C_S are, in a manner, slaves ; it will be seen subsequently that C_R/C_P has a major influence on tooth pitch and C_S/C_P on depth/pitch ratio.

The information may be crystallised about a consistent series of teeth approximating closely to the forms represented by *e*, *d*, and *c* in Fig. 12, flank angle being subjugated to depth/pitch ratio, involving an error of up to no more than 1¼ deg. in any of the forms. The method adopted enables the C factor introduced above to be recast in a way to show quite clearly the effect of the vital variables, unclouded by other variables legitimately subjugated and surviving only as factors in numerical coefficients or as indices of the vital variables. In its amended general form the C factor is

$$C = K \cdot \frac{C_D}{\left(\frac{s}{p}\right)^{0{\cdot}83}\left(\frac{N}{1000}\right)^{0{\cdot}17}} \times \left[\left(\frac{p}{p_f}\right)^{0{\cdot}83} \text{ or } \frac{\left(\frac{s}{p}\right)^{3{\cdot}2} D_e^{0{\cdot}5} \cdot \frac{p_f}{p}}{2{\cdot}6\left(\frac{N}{1000}\right)^{0{\cdot}125}} \text{ or } 1{\cdot}00\right]$$

whichever is greatest

where the theoretically correct pitch, as distinct from p_f the pitch fitted, is

$$p = \frac{D_e}{22{\cdot}2}\left(\frac{s}{p}\right)^{0{\cdot}50}\left(\frac{N}{1000}\right)^{0{\cdot}20}$$

p/p_f in preliminary design being 1·0.

In the expression s/p, p represents the pitch actually fitted and this is not to be confused with the distinction between p and p_f in another term. The possibility of confusion on this point is unavoidable whatever system of symbols is employed in the derivation, and particular reference to the point is warranted.

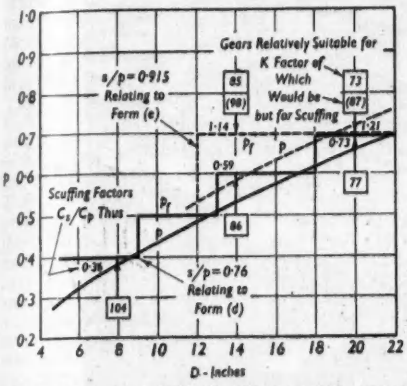
The quantities within the square bracket only contribute to the product if the conditions they represent, respectively root stress and propensity to scuffing, are vital in indicating the limitation of permissible loading. The full significance of the s/p ratio on scuffing is clearly shown.

The next step provides in itself an indication of the significance of the equations to all marine gear design. It is convenient temporarily to adopt the general relationship of diameter to revolutions per minute referred to in Appendix VII, enabling a chart to be drawn showing, for normal materials, p, p_f and C_S/C_P on a base of pinion diameter, taking $D_e = 0{\cdot}875D$. This is shown by Fig. 13, a study of which will reveal the restriction which considerations of scuffing place upon the use of the deep tooth form *e* supporting the view that its satisfactory employment is often to be associated either with limitation of loading or excessive tip relief.

The C_S/C_P and K values relating to the tooth form *d* on the diagram ($s/p = 0{\cdot}76$) show respectively that, for standard materials, there is a good margin for the avoidance of scuffing and that this tooth is suitable for carrying a greater load than the deeper tooth

when proper restriction is placed on the latter against scuffing.

The fact that, but for this restriction, the deeper tooth would carry a greater load and also that the shallower tooth embraces such a substantial margin against scuffing, leads to an examination of the load-carrying capacity of a tooth form intermediate between them having s/p equal to, say, 1·32. Such a form would, on the average conditions portrayed by the diagram, run up to the safe scuffing limit and carry a load represented by K values


Gears Relatively Suitable for K Factor of Which Would be but for Scuffing
s/p=0·915 Relating to Form (e)
s/p=0·76 Relating to Form (d)
Scuffing Factors Cs/Cp Thus
D - Inches

"Standard" materials $D_e^{3}(N/1000)=250$, $D_e=0{\cdot}875D$. Helical angle, 30 deg. $m=0{\cdot}5$.

Fig. 13—Typical load criteria with different tooth forms

midway between those given for form d and those in brackets for form e which would hold good but for scuffing. This represents, for a 20in pitch circle diameter (P.C.D.) pinion, an increased load capacity of 7 per cent over form d and 13 per cent over form e, the sharp characteristic indicating the intermediate form being brought about by the intersection of converging allowable load curves rather than the turning point of a single curve.

Attractive though this may be, the author would not recommend the establishment of such an additional standard, at least at this stage, on account of the following considerations. It is believed that with modern gear cutting and alignment standards, the factors of safety against ultimate fatigue by both pitting and root failure are in fact greater than have been suggested, although the margin against scuffing on a new gear is fairly well established. The form d, by reason of its generous margin against scuffing, would probably permit an increase of nominal loading of at least 7 per cent over the limits suggested in this lecture and as such an increase would not be possible with the intermediate form, the justification for its establishment disappears. Conversely, form d probably provides a more uniform additional margin of safety with the limits proposed. Furthermore, the adoption of higher tensile materials may, by reason of scuffing characteristics, to which subsequent reference is made, favour a reduction rather than an increase in depth ratio.

For these reasons, and having regard to the suitability of form d through the full range of gear sizes, it is appropriate to regard this existing tooth form as a standard upon which to base a specialised statement of the C factor and this should have general application, namely,

$$C=K\cdot\frac{1{\cdot}3C_D}{\left(\frac{N}{1000}\right)^{0\cdot17}}\times\left[\left(\frac{p}{p_f}\right)^{0\cdot83}\text{ or }\frac{D_e^{0\cdot5}\cdot\frac{p_f}{p}}{5{\cdot}85\left(\frac{N}{1000}\right)^{0\cdot125}}\text{ or }1{\cdot}00\right]$$

whichever is greatest

where

$$p=\frac{D_e}{25{\cdot}4}\left(\frac{N}{1000}\right)^{0\cdot20}.$$

With this form of tooth, when normal materials are used, the slave factors within the square brackets are unlikely ever to be significant—that is, to exceed 1·00—particularly as, normally, the pitch chosen would be the standard pitch next above the calculated figure. These calculated pitches are slightly smaller than conventionally adopted, reflecting the author's view that pitch is frequently made excessive.

Table II shows criterion numbers and the C factor for a number of naval and merchant gears. The naval gears show the high C_P values which fast-running all-addendum teeth seem able to sustain and to which reference is made elsewhere. Gear S represents slow-running all-addendum gears which fail by pitting, the sizes being chosen for direct comparison with gear T, and to which the designs U and V also relate.

The use of material constants is introduced in an appendix, whereby

$$C_P'=K.k_P/C_{MP}$$

$$C_R'=K.k_R/C_{MR}$$

and

$$C_S'=K.k_S/C_{MS}.$$

C_{MP}, C_{MR}, and C_{MS} are unity for the materials currently regarded as standard. To avoid complication these constants have been excluded from the equations leading to the final C factor, which is now repeated to show the characteristic of their employment and termed C_R'.

$$C=K.\frac{1{\cdot}3\frac{C_D}{C_{MP}}}{\left(\frac{N}{1000}\right)^{0\cdot17}}\times\left[\left(\frac{p}{p_f}\right)^{0\cdot83}\text{ or }\frac{D_e^{0\cdot5}\cdot\frac{p_f}{p}}{5{\cdot}85\left(\frac{N}{1000}\right)^{0\cdot125}\cdot\frac{C_{MP}^{2\cdot25}}{C_{MS}C_{MR}^{1\cdot25}}}\text{ or }1{\cdot}00\right]$$

whichever is greatest

and

$$p=\frac{D_e}{25{\cdot}4}\left(\frac{N}{1000}\right)^{0\cdot20}\left(\frac{C_{MP}}{C_{MR}}\right)^{1\cdot25}.$$

The latter equation, taken in conjunction with the expressions for C_{MP} and C_{MR} in terms of U assumed in an appendix, shows that for an established s/p ratio desirable pitch varies as $\sqrt[4]{U/45}$.

If the material constants are applied to the previous and more general statement of the C factor, which approximately covers the e, d, c tooth series, it is seen that the scuffing or depth/pitch slave factor embraces the multiple

$$\left(\frac{s}{p}\right)^{0\cdot3}\frac{p_f}{p}\cdot\frac{C_{MP}^{2\cdot25}}{C_{MS}C_{MR}^{1\cdot25}}\text{ or }\left(\frac{s}{p}\right)^{3\cdot2}\frac{p_f}{p}\cdot\left(\frac{U}{45}\right)^{1\cdot45}\Big/C_{MS}.$$

Thus, if

$$\left(\frac{U}{45}\right)^{1\cdot45}\Big/C_{MS}>1{\cdot}0,$$

as is quite likely in the employment of advanced materials to which reference is made later, immunity from scuffing is reduced and when the safety limit is reached K ceases to benefit further in proportion to C_{MP} and unless C_{MS} is artificially raised by the use of an E.P. lubricant, either s/p must be reduced, possibly rendering desirable a new tooth form intermediate between d and c, or p_f must be reduced. Within the scuffing zone reference to the same statement of the C factor will show that reduction in s/p will permit further load increase inversely proportional to the ratio of reduction raised to the power (3·2−0·83) or about 2¼. On the other hand, unless p_f is larger than necessary (in which case K may be increased inversely proportional to a reduction in p_f) the allowable gain in K due to reduction in p_f is negligible, since the root stress slave factor suffers to almost the extent that the scuffing slave factor benefits.

These considerations are essential to research on gears with advanced materials to ensure that comparison is being made between optimum conditions.

(To be continued)

TABLE II

Gear	Naval vessels quoted by Joughin (1951)								Merchant vessels					Alternative designs for S or T	
	"Egret," "Pelican," and "Sutlej"	"Hunt" class destroyer	Italian cruisers	"J" and "K" class destroyers	"Dido" (cruising turbine)	"Bittern"	"Erne" and "Ibis"	"Formidable"	P	Q	R	S	T	U	V
D, inches	5·14	8·78	14·3	10·93	6·0	5·14	5·44	18·2	5·99	9·21	13·86	16·71	16·71	16·71	16·71
D_e, inches	4·77	7·87	12·95	9·84	4·4	4·77	5·06	16·31	5·41	7·9	12·18	14·84	14·84	14·84	14·84
$W+G$, inches	12+3	24½+3	45½+3	32+3	8+3	12+3	15·7+2	52+3	16½+3½	20+3½	27+3	38+3	38+3	38+3	38+3
N	3700	3300	2631	3070	6500	3700	4030	2000	3000	5000	8000	829	829	829	829
P	616	918	1070	1098	540	564	462	1281	459	606	1437	1010	1010	1010	1010
p, inches	7/22	7/22	1/22½	7/22	7/22	7/22	4/22	7/22	7/22	9/19	1·047	7/22	7/22	7/19	8/19
πn, deg.	22½	22½	22½	22½	22½	14½	22½	22½	14½	16	20	22½	14½	16	16
s/p	0·636	0·636	0·636	0·636	0·636	0·636	0·636	0·636	0·636	0·760	0·636	0·636	0·914	0·760	0·760
σ, deg.	30	30	30	30	30	30	30	30	36·4	42	30	30	30	30	30
m	1	1	1	1	1	0·5	1	1	0·5	0·6	0·5	1·0	0·5	0·6	0·6
$K=P/D_e$	129	116	83	111	123	118	91	78	85	77	118	68	68	68	68
C_D	1·27	1·68	1·71	1·75	1·00	1·16	1·81	1·53	1·34	1·00	1·10	1·26	1·16	1·15	1·16
C_P	219	267	200	270	149	163	219	179	141**	78	201**†	149**	90	107	108
C_S	149**	135**	145**	124*	80	72	88	74	62	44	165*‡	103	120*	94	81
C_R	85	168	116	209	59	77	133	214*	77	63	97†	116	83	85	97
C	219	267	201	270	149	163	219	207	141	77	—	149	119	106	107

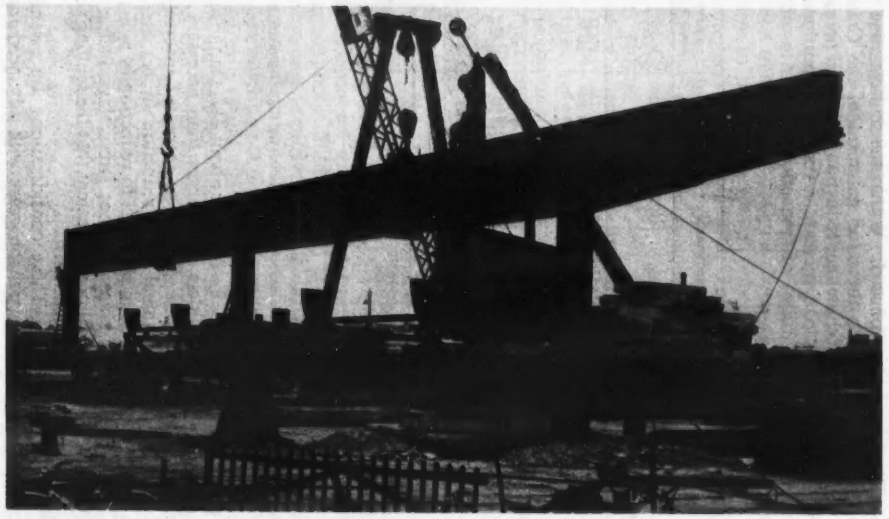
Gears which have pitted, scuffed, or suffered from broken teeth shown **. Varied experience with different gears of the class *.

† To correct for 65 tons U.T.S. pinion steel $C_P'=C_P/C_{MP}=130$, $C_R'=C_R/C_{MR}=67$.

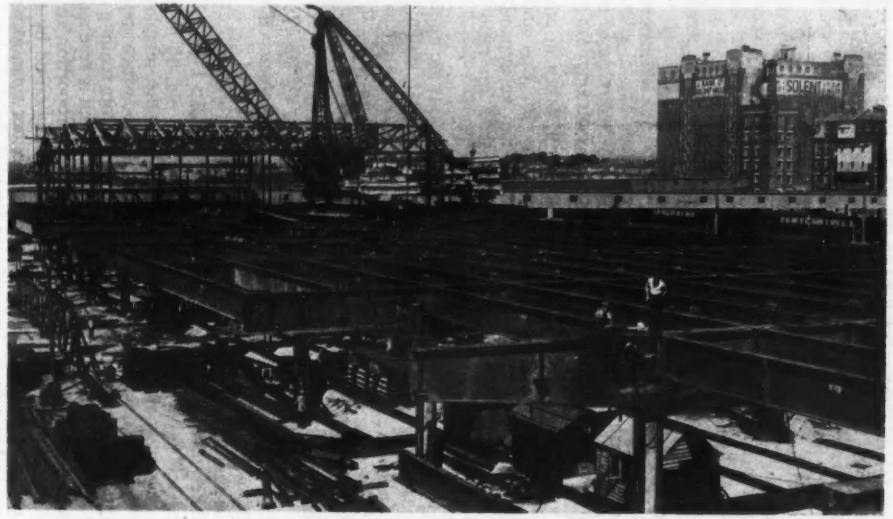
‡ History unknown in relation to C_{MS} factor, but scuffing probably led to pitting on a reduced surface.

C has been calculated from the general expression derived for the consistent series of tooth forms and shows, by its variation from the maximum of individual C_P, C_R or C_S values, typical effects of using other tooth forms.

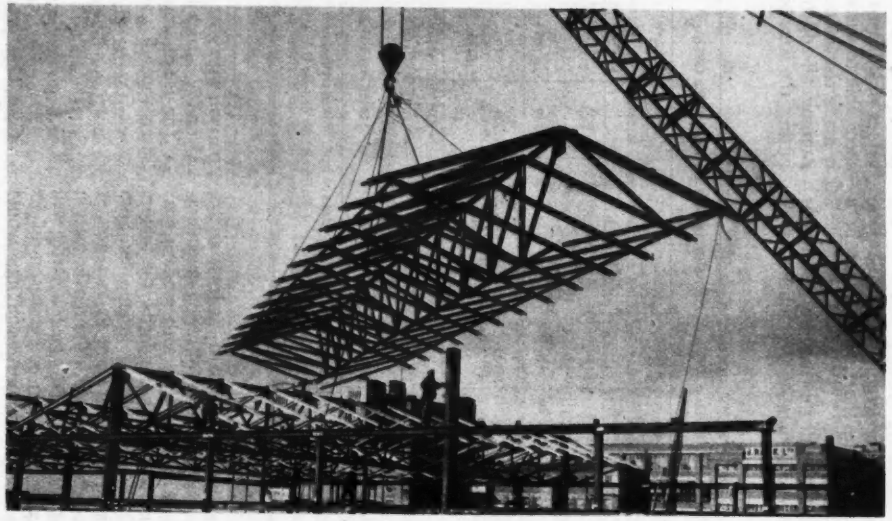
STEELWORK OF THE NEW PASSENGER AND CARGO BUILDING AT SOUTHAMPTON



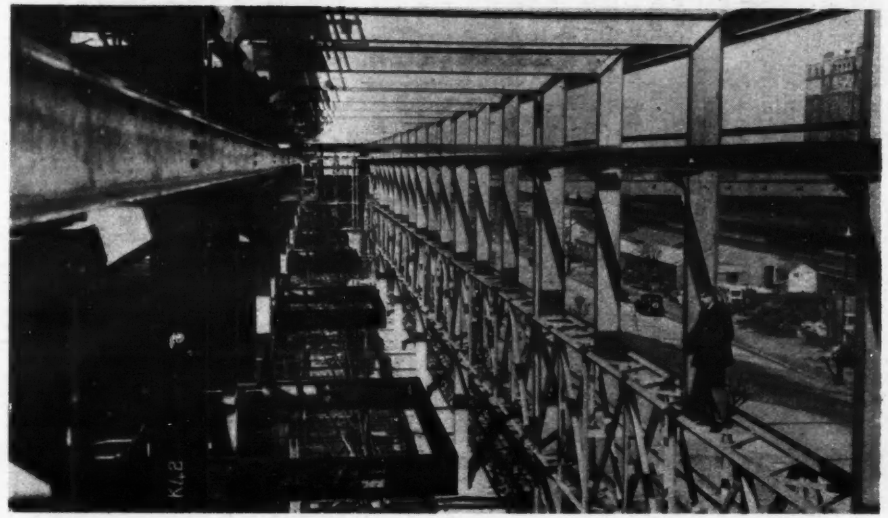
Erection of main girder. The main girders each have two 54ft spans and a 22ft cantilever, and are placed transversely across the shed at 49ft centres



The floor steelwork is designed for 3 cwt per square foot loading, with welded continuous secondary girders. Roof steelwork is shown in the background, and a fabrication of a roof truss assembly on the left



Erection of a roof frame of 108ft span. The central N-braced truss has rafters on each side propped from its bottom chord. Extra bracing on one side of the truss gives torsional strength.



Steelwork in the gantry bay. Overhead travelling cranes will load from the platforms to railway trucks below

Steelwork of the New Passenger and Cargo Building at Southampton

LAST week, a new passenger and cargo building was opened at Southampton by the High Commissioner for the Union of South Africa, Mr. G. P. Jooste. The building is for the South African services of the Union-Castle Mail Steamship Company, Ltd., and gives a covered area of about 6 acres on two floors. The ground floor has passenger terminal facilities, but is also used for cargo in transit, and the first floor is entirely for use as a transit shed. The building is 932ft in length by 162ft wide in its central part.

The main engineering interest of this new building is in the design of the structural steelwork. The building has a welded steel frame, carrying heavy loads over appreciable spans, and employs a novel method of roof construction. The steelwork carrying the first floor was designed according to the "collapse load" method, and the building is probably the first one of such magnitude where collapse methods of design have been employed. The amount of repetition and size of the members made automatic welding almost an essential approach to the shop fabrication of the steelwork, and, in addition, considerable welding was done on the site. The design and construction of the steelwork was discussed on Thursday, January 26th, at the Institution of Structural Engineers, when the paper "Steelwork in Transit Shed 102, Southampton Docks," by Mr. F. M. Bowen and Mr. B. E. S. Ranger, was presented. The accompanying illustrations give a good idea of the size and form of the shed steelwork. The description of it in the following paragraphs has been abstracted from the paper.

The main girders run transversely across the shed at 49ft centres, spanning the two 54ft bays and cantilevering 22ft to support most of the 33ft 4in landing platform, which is completed by linking beams to the outermost stanchions. This arrangement was necessary in order to keep the loads on the outermost stanchions within the limits permissible on the existing quay structure upon which they stand. The west end contains bays of various other dimensions. The main girders are of all-welded plate construction with 6ft deep webs, except for the cantilevers which taper to 4ft. Flanges are single plates with butt weld joints, 20in wide for intermediate main girders and 12in for the expansion joint girders, which are arranged in pairs to allow relative movement. Thickness of the girder flanges varies between 1in and 2⅞in. These girders, 132ft long, were transported to the site in halves, and a site welded joint made in a rotating jig before they were erected.

The main stanchions supporting the first floor steelwork are of welded I-section with 16in or 20in webs and 20in wide flanges (12in at expansion joints), provided with welded bases designed to resist moments due to wind forces and eccentricity of the reactions from the girders. They incorporate simple cap plates to form direct bearings for the continuous main girders and do not continue upwards to carry the roof structure.

The 49ft span secondary girders are also welded I-section plate girders with webs generally 3ft 6in deep and 12in wide flanges varying from ⅜in to 1¼in thick. They have end stiffeners only.

All these secondaries were designed as continuous over several spans and required full-strength through connections at the main girders. Briefly, the arrangement adopted was as follows:

(*a*) Web plate butt welded to stiffener on main girder.

(*b*) Top (tension) flange carried over main girder flange and butt welded to corresponding flange of next span.

(*c*) Bottom flange butt welded to stub flange on main girder.

The main roof framework is made up principally of four groups of standard parts, namely:

(i) "N" braced lattice girders spanning the full 108ft from side to side of the shed and supported on main stanchions at 49ft centres.

(ii) Plain joist rafters at 9ft centres on each side of the lattice girders, supported at the top chord node points and by props to the bottom chords.

(iii) Tees bent to form valley members and slung between the lower ends of the rafters in adjacent bays, which ends are cantilevered over the supporting props for this purpose.

(iv) Torsion bracing systems, the full length on one side of each roof girder in the planes of the rafters and props, forming with them and the girders triangular braced boxes to resist overturning by unbalanced loading.

The lattice girders and stanchions were designed to form transverse portal frames to carry wind forces and part of the lateral forces from the gantry bay cranes. The roof and gutter decking spans directly across the rafters and valley slings and contains glazing panels; thus there are no purlins.

In each gable, strut members to the outer points of the torsion bracing boxes from the tops of intermediate stanchions transfer the resultants of overturning forces into the side framing and thence to the first floor steelwork below. The intermediate wall stanchions also act as door posts. Torsion bracing systems were introduced into each roof bay first to prevent progressive collapse in the event of fire or war damage; secondly, to stiffen the framework so that each complete unit, i.e. girder with the outrigger triangles on both sides, could be lifted into position in one piece, and thirdly, to enable the valley slings to be reduced to minimum practicable size and have simple connections for easy fixing in the air. (Without torsion bracing in each bay, these slings would have to carry the moments deriving from shear between adjacent frames.)

The roof structure of the narrower east and west ends of the shed differs from that described only in that some of the lattice girder and bracing members are lighter, so that a high degree of standardisation was afforded throughout.

All the members in the lattice girders are of angles welded together toe-to-toe to form hollow sections with the corners placed vertical and horizontal and slotted for insertion and welding of gussets. Appropriate variations in strength of the chord members was obtained simply by changing the thickness of the angles. Similar members were used for the torsion bracing and rafter props and in all cases, to prevent interior corrosion, open ends were sealed by welding in small plates.

From the outset it was envisaged that each girder, together with its outriggers and ties, should be assembled and welded on the ground and then lifted into place in one piece. The outriggers would automatically provide the requisite stiffness to the long girders for erection and only the valley slings and ties would remain to be fixed *in situ*. This procedure was in fact adopted by the contractor and worked very well.

This roof provides a first floor area completely clear of obstructions. The weight of the framework over the 108ft span, excluding stanchions, is 7·1 lb per square foot of plan area. For cleaning and painting, the superficial area is only about 46 per cent to 48 per cent of that of a comparable design with "orthodox" girders and sections. The reduction on the girders alone is approximately 55 per cent. Such reductions must produce savings in both time and cost of maintenance, which, in a building of this size, are so considerable as to have a significant effect on long-term economy.

The 442ft long gantry bay on the north (road) side accommodates four 30 cwt electric travelling cranes to handle cargo between the first floor and the rail track below. The main gantry bay frames, which are one-legged portals with the roof beam ends supported on the main roof stanchions, are spaced at 49ft centres longitudinally corresponding with the main stanchions in the shed. The outer legs of the intermediate portals, at third points between the main frames, are carried on continuous lattice box girders and the inner legs are supported on beams along the edge of the first floor. The main and intermediate portals are of welded construction, and welded site joints were formed at the knees. The lattice girders were shop-welded in sections and site welded joints made so that they became continuous girders broken only at the expansion joints. As the gantry bay is open to the weather and to the effect of steam and smoke from locomotives passing through, a ⅛in minimum thickness for small sections was adopted.

From the designing engineer's point of view, once he has retuned his mind and become accustomed to the "collapse load" method, it has attractions. It appears logical, is quite speedy and affords latitude in the disposal of material in (built-up) members. This last point has considerable practical value, especially when the work is in the upper range of plate sizes and thicknesses. Appreciable reductions in the amounts of material also are possible and produce real advantages in heavy structures (this is not axiomatic for light frameworks because the limit beyond which the cost of extra labour in erection, &c., exceeds the saving on material is reached much sooner). Though in this case the reduction was partially offset, it was still appreciable; on a typical line of secondaries and a typical main girder, it was about 8 per cent, as compared with similar welded continuous members designed "elastically."

The present position on the designing of stanchions is less encouraging and, in the authors' opinion, progress in this field has lagged behind the utilisation in practice of up-to-date knowledge of beams, girders and portal frames.

Reviewing the "propped rafter" roof, suitable tubes were unobtainable when this work was done but obviously would be suitable for almost all the members except the rafters and valley slings and would save much labour in welding. However, the method of adjusting the main chord strengths by varying the thickness only of the components was proved to be good and has further possibilities. The valley slings are fairly flexible and the theoretical minimum size will not necessarily always be the most economical; ease of handling and fixing them should be borne in mind.

It is particularly important when designing and detailing all-welded continuous structures to envisage and keep in mind at all times, fabrication, transport and erection methods and limitations. It should be realised that no matter what precautions are taken, distortion cannot always be eliminated entirely and slight discrepancies in fabrication may occur. Full allowances for consequent adjustments and for rolling depth variations should always be made, e.g. by including packings, in the joint details.

In this project, the final choice of the large 54ft by 49ft main stanchion grid and framework layout for the first floor was determined primarily by the better traffic handling facilities afforded by it and the consequent long-term savings in costs which more than balanced the initial extra expenditure on the steelwork as compared with possible smaller grids. This choice, in turn, prompted the adoption of a welded structure and the "collapse load" method of design to reduce the weight of steel and maintenance painting costs. Again, in the upper storey traffic handling facilities and costs led to a clear span roof, and subsequently it was from thoughts on the other desiderata, especially reduction of maintenance, combined with a belief that there are advantages to be gained from erecting light steel framework in large portions, that the idea of the "propped rafter" roof was born. Incidentally, the weight and initial cost of this roof are not uneconomical as compared with other types suitable for long spans.

The consulting structural engineers for the building were Scott and Wilson, Kirkpatrick and Partners, who worked throughout in conjunction with Mr. J. H. Jellett, M.I.C.E., the docks engineer. The steelwork contractor was The Fairfield Shipbuilding and Engineering Company, Ltd.

AIRCRAFT EXPORTS.—British aviation exports during 1955 totalled £66,190,000; exceeding the highest figure previously attained, that of 1953, by nearly £50,000. On average the last six months of the year ran £800,000 above the first six, auguring well for 1956.

Potentialities of Railway Electrification at Standard Frequency

By E. L. E. WHEATCROFT, M.A., M.I.Mech.E., M.I.E.E., and H. H. C. BARTON, B.A., M.I.Mech.E., M.I.E.E.*

No. I

In a paper presented at the Institution of Electrical Engineers in London yesterday the authors discussed the technical and economic aspects of railway electrification with alternating current at standard frequency. Accepting d.c. electrification as a satisfactory method for suburban railways, the authors suggest that, for the new main line projects in Great Britain the 50 c/s system is likely to be cheaper than others and may be installed without technical difficulty. Abstracts from the paper are given here.

UNTIL the end of the second world war the so-called "battle of the systems" lay between the direct-current system, in which current at voltages of up to about 3kV was supplied to trains powered with series-wound traction motors, and the low-frequency a.c. system, whereby single-phase current at 11–16kV was supplied to the trains and thence by transformer, in most cases direct to a.c. commutator motors. Motor design difficulties necessitated the adoption of a frequency lower than standard, i.e. 16⅔ c/s or 25 c/s, requiring current to be supplied to the line either by special alternators located at the traction substations and driven by three-phase motors from the standard frequency supply or, as in Germany, Switzerland and parts of the United States, from special low-frequency generating stations.

The series-wound d.c. motor has proved particularly suitable for traction, but because of motor commutation voltage limitations the d.c. system suffers the disadvantage of having to operate at a comparatively low line voltage and with high currents. This necessitates more costly fixed equipment because of the relatively large conductor section and the greater number of substations which are required.

With the a.c. system, incorporating transformers on the rolling stock, much higher line voltages were possible, resulting in lower line currents. This permitted lighter and cheaper track equipment and fewer substations, and reduced the cost of fixed equipment even after allowing for the conversion equipment to supply the low-frequency current. It was always obvious that the cost of fixed equipment could be reduced still further if technical advances would allow the trains to be supplied with alternating current at standard frequency, as the substations would then be merely transforming stations, while the high line voltage would permit light track equipment and well-spaced substations as in the low-frequency case.

HISTORICAL

Roughly two-thirds of the world's electric railway route mileage is d.c. operated, and one-third is a.c. operated, comprising a varied assortment of voltages and frequencies. In Europe there are some 9000 route-miles equipped at 16⅔ c/s, this being the system adopted by the national railways of Austria, Germany, Sweden and Switzerland. In all these countries the low-frequency a.c. system proved successful on technical grounds, and extensions of electrification were therefore justifiably carried out using the same system.

In the United States trends differed. The electrification of sections of the Chicago, Milwaukee, St. Paul and Pacific Railroad at 3kV d.c. in 1915, before the static rectifier had been developed for traction, conflicted with the decisions of some other lines to adopt 11kV 25 c/s. However, at that time 60 c/s had not been established as a national standard and 25 c/s industrial frequency networks existed; there were in fact two standards. Perhaps, therefore, America may be credited with being the first country to adopt a standard frequency for railway electrification, because the 16⅔ c/s system, which had already proved successful in Europe, was rejected in favour of an existing industrial standard.

In the 1920s, in the British spheres of interest in South America, South Africa, Australia and India, a large mileage was equipped for d.c. operation with rotary converter substations.

* Messrs Merz and McLellan.

By the late 1930s static rectifiers were well established for traction applications (they had been used on the Midi Railway since 1922), and the Italian Railways decided to adopt the 3kV d.c. system. At this time only a very limited experience had been obtained with 50 c/s for traction, the alternatives being the d.c. system with its excellent motor characteristic and now cheapened and improved technically by the rectifier, and the low-frequency a.c. system, which still offered lower fixed equipment costs on account of its higher operating voltage. This Italian decision, which was supported by similar decisions in Eastern Europe, Belgium and Holland, as well as by the Lackawanna Railroad in the United States, is significant because it involved a new major project (the three-phase system in the Italian northern provinces was time expired), and it was taken when extensive experience had been obtained with each alternative.

In France extensions of electrification were put in hand after the second world war by the Société Nationale des Chemins de Fer Français, under whose direction the railways were by then fully nationalised. Prior to this, several years' satisfactory experience had been obtained with a 50 c/s system in Hungary, equipped in 1932 between Budapest and Komárom and later extended to Hegyeshalom. The German State Railways had tried different types of rolling stock on the experimental 50 c/s Hollental line, which had been operating thirty-five electrified route-miles since 1936. In order to consolidate and extend this experience the French Railways opened a short experimental 50 c/s section in Savoy in 1950. This was considered so successful that the standard frequency system has been adopted for the major electrification projects in N.E. France, the first section of which was opened to traffic between Valenciennes and Charleville in 1954. This decision is the more significant because, apart from the large mileage involved, it was taken in spite of the fact that some 2000 route-miles of successful 1·5kV d.c. railway electrification already existed in the French central and south-western provinces.

While these developments were proceeding the Chemin de Fer du Bas-Congo au Katanga embarked upon a major 50 c/s project in the Belgian Congo. First opened in 1952 between Jadotville and Tenke, this has now been extended to Kolwezi, and a further section is under construction to Elisabethville. In Great Britain and Russia trials have also been made with this system, the Lancaster, Morecambe and Heysham section of British Railways having been in successful revenue service for over two years after conversion to 50 c/s operation.

Table I summarises the published particulars

TABLE I—*Railway Electrifications at the Standard Frequency which have been Completed or Proposed (Position at* 1955)

Railway	Route	Route-miles	Track-miles	Line voltage	Rolling stock	Completion date
		miles	miles	kV		
Hungarian State ...	Budapest-Komárom	56	404	16	36 locomotives	1932
Hungarian State ...	Komárom-Hegyeshalom	61			4 railcars	1934
Hungarian State ...	Budapest extensions	23	†	†	†	1952
D.B. (Hollental) ...	Freiburg-Seebrugg-Neustadt ...	35	57	20	5 locomotives 1 motor-coach	1936
S.N.C.F. (Savoy) ...	Aix-les-Bains—La Roche-sur-Foron	48	50	23	4 locomotives 4 motor-coaches	1950–51
B.R.	Lancaster-Morecambe	10	19	6·6*	3 motor-coaches	1953
B.C.K. (Congo) ...	Jadotville-Tenke	64	130	25	12 locomotives	1951
B.C.K. (Congo) ...	Tenke-Kolwezi	62				1953
B.C.K. (Congo) ...	Jadotville-Elisabethville	84	100		10 locomotives	Uncompleted
S.N.C.F.	Valenciennes-Charleville	83	256		105 locomotives	1954
S.N.C.F.	Charleville-Thionville	90	294			
S.N.C.F.	Thionville-Reding-Basle	193	710	25	85 locomotives	Uncompleted
S.N.C.F.	Valenciennes-Lille	35	109			Uncompleted
S.N.C.F.	Dijon-Vallorbe	105	†			Uncompleted
S.N.C.F.	Dole-Mulhouse	112	†	P		P
U.S.S.R. State ...	Lichoslaul (Kalinen-Boogoje) ...	38	†	22	† locomotives	1951–52
U.S.S.R. State ...	Ozherelye-Pavelets	62	†	22	† locomotives	1955
Turkish State... ...	Istanbul Suburban	17	†	25	36 motor-coaches 3 locomotives	1955
Portuguese State ...	Lisbon-Entrocamento (1st stage) ...	92	180	25	15 locomotives	
Portuguese State ...	Entrocamento-Oporto (2nd stage)	150	284		25 3-car units	†
Argentine and Chile	Mendoza-Los Andes	125	†	27	11 locomotives	P

* Provisional voltage because some original 6·6kV line equipment is being used for this experimental section.
† Some oversea details have yet to be obtained.
P=Proposed.

TABLE II—*Particulars of 50 c/s Series-Wound Commutator Traction Motors Built or Proposed (Position at* 1955)

Type No.	Design	No. of poles	One-hour rating			Weight	Manufacturers	No. of motors ordered or proposed	Where operating or proposed for operation
			Voltage	Current	Speed				
			Volts	Amp.	M.p.h.	lb			
TDM.627 ...	Twin ...	2×12	2/218	1,600	61	11,100	Alsthom ...	7	In service on loco CC 20002 Savoy section, S.N.C.F.
16WB880 ...	S.A. ...	16	250	2,780	40	6,520	Oerlikon ...	51	In service on loco CC 20001 Savoy section, S.N.C.F. 44 motors are ordered for locos 25001–7 for Savoy extensions, S.N.C.F.
20WB1140 ...	S.A. ...	20	283	3,760	53	8,800	Oerlikon ...	10	For locos BB.30001–2 for extensions to Basle, S.N.C.F.
14HW750 ...	S.A. ...	14	251	1,670	36	3,750	Oerlikon ...	5	In service on motor-coach Z9051 Savoy Section, S.N.C.F.
MS92	S.A. ...	18	260	3,000	33	9,600	Jeumont ...	218	36 motors on "BB" class 13000 locos in N.E. France; a further 182 proposed for extensions
MS93	S.A. ...	18	365	2,900	58	9,800	Jeumont ...	—	Prototype motor proposed for subsequent S.N.C.F. electrifications
EKB750 ...	Tandem	2×12	2/235	1,490	46	7,480	A.E.G.	4	In service on loco E.244.22 Hollental section : DB
WBM196 ...	Twin ...	2×14	2/243	1,370	47	5,500	Siemens... ...	8	In service on loco E.244.21 Hollental section : DB
WBM244 ...	S.A. ...	12	220	1,970	38	5,610	Siemens... ...	4	In service on motor-coaches ET.255 Hollental section: DB
MS51	Twin ...	2×10	2/240	850	29	5,925	A.C.E.C. ...	48	In service on the 12 locomotives of the B.C.K. Railway, Belgian Congo
MN93 ...	S.A. ...	18	235	2,420	30	7,700	A.C.E.C. ...	40	For a further 10 locos of the B.C.K. Railway
KJ107	S.A. ...	14	242	3,150	*	7,250	A.S.E.A. ...	—	Prototype motor under test
TAM639 ...	S.A. ...	12	260	1,400	39	4,840	Alsthom ...	72	Istanbul Suburban (motor-coaches)
MS72	S.A. ...	14	300	1,880	37	6,380	Jeumont ...	12	Istanbul Suburban (locomotives)
†	†	†	230	1,200	39	3,520	†	100	Lisbon Suburban (motor-coaches)

Notes: S.A. Single armature.
* Rating at 70 per cent full speed.
† Details to be obtained.

of all the standard-frequency systems which have been completed or proposed to date, including recent projects in Turkey and Portugal.

Rolling Stock for 50 c/s Operation

Three basically different types of rolling stock are available for standard-frequency electrifications, all of which may be seen in operation. They are the a.c.-motored type, the motor-generator type with d.c. motors or a.c. induction motors, and the rectifier type with d.c. motors. The technical details of these types are described in references [at the end of the paper] and discussion is therefore confined to the assessment of the performance of these types so far as experience permits. This experience under different service conditions is limited, and there has hardly yet been time for the maintenance departments to contribute worthwhile opinions.

50 c/s Motored Rolling Stock.—To date, about fourteen different designs of 50 c/s commutator traction motors have been built, and details of these are given in Table II. Some of these have not yet entered service, while others are acknowledged prototypes.

Single-phase traction-motor design is fundamentally difficult because of the "transformer e.m.f." which is induced between field and armature, resulting in the armature windings having to carry excessive currents when starting which are not torque-producing. This necessitates a design compromise between the provision of a large commutation area and operation at a comparatively weak flux per pole with a consequential increase in the number of poles (and, therefore, brushes) in order to obtain adequate starting torque. This difficulty, significant at low frequencies, increases appreciably as the frequency is raised, until at 50 c/s the incorporation of additional design techniques or combinations of these techniques becomes essential. These include tandem or twin construction, field shunting on the early starting notches in order further to reduce the flux, the incorporation of resistive elements within the armature windings to reduce the non-torque-producing currents, and resistive shunting of interpoles to improve commutation. These features tend to complicate motors and equipment to the disadvantage of maintenance as well as increasing motor size and weight. [The authors gave a comparison between the sizes and weights of 16⅔ c/s and 50 c/s traction motors designed for similar duties and made by the same manufacturers: 16⅔ c/s, diameter 2ft 11½in, length 2ft 11½in, weight 5350 lb; 50 c/s, diameter 3ft 5¾in, length 3ft 2½in, weight 7250 lb.]

So far as it is possible to judge, the 16⅔ c/s traction motors in service on the Continent have a better maintenance record than the 25 c/s motors in service in America. Nothing the authors have seen of 50 c/s traction-motor maintenance work suggests an easing of this trend; indeed, they are of the opinion that the opposite may be the case as more operating experience is obtained with 50 c/s machines.

For multiple-unit applications, where forced starts and rapid accelerations are an essential requirement, the 50 c/s traction motor has a better chance provided that it can be accommodated within the limited space usually available and within the axle loads permitted. The total weight of 50 c/s and 16⅔ c/s equipments for multiple units as well as locomotives would be about the same, the heavier 50 c/s motors being offset by the lighter 50 c/s transformer. The objections to 50 c/s traction motors, therefore, lie in the maintenance problem which they are likely to present, coupled with an unavoidable increase in unsprung weight if they are axle-mounted.

Motor-Generator Rolling Stock.—Motor-generator locomotives may be designed either with d.c. generators and d.c. traction motors or with single-phase/three-phase motor-alternator sets and three-phase induction motors. In the former case, speed control is obtained by varying the d.c.-generator output, while in the latter case this is done by varying the frequency at the traction motors. Both types have a poor power/weight ratio, which renders them less economical for mixed traffic duties. They may, however, be designed for a unity or leading power factor, with the result that they help to boost the line voltage when operating in conjunction with other types.

The d.c.-motored type has excellent starting and slow-running characteristics, and it is best suited to conditions which permit heavy freight trains to be worked entirely by a locomotive "link" comprising this type. This is evidenced by their remarkable performance operating the coal traffic on the Virginian Railway. The control equipment for varying the generator field strength is comparatively simple, and the regenerative brake feature may be incorporated easily.

The frequency changer type is technically more versatile because better performance may be maintained into the higher speed ranges. There are two main versions of this type. Earlier versions used in Hungary have wound-rotor induction motors with slip rings fed at a number of fixed frequencies, intermediate speeds being obtained by resistance control. In one case four fixed frequencies are obtained by traction-motor pole-changing, while in another a frequency changer is coupled to a phase convertor and runs at synchronous speed, five fixed frequencies being obtained by pole-changing and varying the direction of rotation of the frequency changer field. A later version recently ordered by the French Railways has squirrel-cage traction motors in which the phase convertor and frequency changer are each coupled to a separate d.c. machine for Ward Leonard control. The phase convertor rotates at synchronous speed, but the frequency changer, having variable speed control, enables a continuous frequency variation between 0 c/s and 135 c/s to be applied to the traction motors. This latest version possesses most of the advantages of the a.c./d.c. type with perhaps an added one, because the squirrel-cage induction motors should require less maintenance than even d.c. machines.

The main objections to the frequency changer type of locomotive seem to lie in its complication and the low power/weight ratio. The latter objection becomes more significant when the locomotive is used for the wider range of duties for which its performance is suitable. These disadvantages will generally preclude the use of motor-generator transformation for multiple-unit applications.

Rectifier Rolling Stock.—Many factors point to rectifier-equipped rolling stock with d.c. traction motors providing the best all-round answer—an opinion the authors have held for some time. Following very successful trials on the Pennsylvania Railroad with a rectifier motor-coach in 1949 and, more recently, with two large rectifier locomotives, ten locomotives and 100 multiple-unit coaches of this type have been built for operation on the New York, New Haven and Hartford Railroad, and six two-unit, 6000 h.p. rectifier locomotives have been ordered by the Virginian Railway. These are significant moves to make on 25 c/s systems, where the problems of a.c. traction-motor design are less exacting than is the case on 50 c/s systems. Furthermore, on the French Railways, where more experience of different types of standard frequency rolling stock has been obtained to date than elsewhere, rectifier locomotives are being ordered in increasing numbers, following the good results obtained with those already in service in N.E. France. Altogether there are now about 170 rectifier locomotives and 105 rectifier motor coaches in service and on order for different railways.

Rectifier rolling stock enables the well-proven d.c. traction motor to be adopted; indeed, in America, existing standard d.c. motors have been used. This type also offers scope for relatively simple and efficient dual-system operation, which may be advantageous if main line electrification projects embrace an existing d.c. system over part of the route. This consideration weighed with the New York, New Haven and Hartford Railroad in their decision to adopt rectifier designs both for locomotives and multiple-unit stock for interrunning with the New York Central d.c. system, although it is understood that the primary justification lay in the wish to adopt the more easily maintained d.c. traction motor.

So far, except for a few multi-anode experimental equipments, most of the service experience with rectifier rolling stock has been obtained with the single-anode ignitron rectifier. British Railways have, however, successfully used air-cooled "excitrons" on one of the Lancaster, Morecambe and Heysham motor coaches, and the French Railways are also carrying out experiments with this rectifier, which may offer some reduction in complication by the simplification of the "firing" equipment. Nevertheless, it may be said that the ignitron rectifier, although requiring firing as well as water cooling equipment, which were expected to be disadvantages during the early application stages, has now established itself as an easily accommodated and acceptable proposition for railway applications.

Already the French Railways claim that a comparable 50 c/s ignitron locomotive is capable of a better performance than its all-direct-current counterpart. This results from the transformer tap method of control, whereby a large number of starting notches may be incorporated easily, and from the improved adhesion which is obtained with parallel-connected traction motors. While this improved adhesion is a feature of all rolling stock having parallel-connected traction motors, irrespective of whether they are a.c. or d.c. operated, it can be used to better advantage with d.c. motors having high saturation. On straight d.c. locomotives the adhesion qualities cannot be so good because the traction motors are series connected during starts. This results in a tendency for slipping to be cumulative owing to a voltage build-up across the motor of the slipping wheel, combined with the falling off of tractive effort at those wheels which are gripping.

In the field of rectifier alternatives it must not be overlooked that rapid progress is being made with the development of semi-conductor rectifiers for heavy and fluctuating current duties. It is certain that their application to traction is not far distant, with a consequent simplification of equipment both in design and layout and an appreciable saving in space and possibly weight. Their rigid construction seems well suited to traction applications.

The authors consider that the trend in favour of rectifier equipments is likely to continue, because they may be designed to be comparable in performance with straight d.c. equipments without occasioning any increase in maintenance. Given reasonably large orders, rectifier locomotives should be no more costly than 3kV d.c. types. The purchase of rectifier rolling stock for three 25 c/s American railways, as mentioned above, is an important pointer.

Dual System Operation.—Rolling stock may be designed for inter-running between a high-voltage a.c. traction system and a lower-voltage d.c. one. Designs having d.c. traction motors supplied from rectifiers are very suitable for this because the rectified voltage may be selected, as in the case of the New Haven Railroad, to enable the traction motor circuits to be fed direct when in d.c. territory. Dual system rolling stock of this type requires resistance control for operation from the d.c. system, and it may therefore be more economical to use this resistance control instead of transformer tap control when on a.c. territory, thus avoiding duplication of equipment.

Where dual system operation between a high-voltage a.c. system fed from overhead conductors and a low-voltage d.c. system fed from current rails is required, the track equipments may overlap. This permits automatic change-over from pantograph to shoegear and vice versa, with only a short coasting period while the transition switchgear operates. Inter-running in this way offers an alternative deserving of economic consideration if clearances for the entry of an overhead line high-voltage system into or through large cities prove excessively costly to obtain.

Dual system operation between a high-voltage a.c. system and a d.c. one having overhead conductors presents additional problems, not the least of which is that of pantograph design. The switching arrangements may be similar to those used in the former case, but higher-voltage traction motors would have to be installed than would be necessary if rectifier locomotive operation were limited to a.c. territory.

Dual system operation between a standard frequency a.c. system and a suburban d.c. system is easier than it would be between, say, a 3kV d.c. system and a lower-voltage suburban one. The

latter would require the installation of complicated switchgear in each locomotive, and the traction motors would have to be insulated for the higher voltage and wound for the lower one. Perhaps the worst feature of d.c. to d.c. dual-voltage designs is that the traction motors must remain series connected while operating from the higher-voltage system, where it is likely that a greater running time will be spent.

These considerations of inter-running are based on the assumption that rolling stock should be capable of the most efficient operation on both systems without involving drivers in extra duties such as changing motor combinations or controller notches in order to obtain the desired performance when running from one system to another. The manual monitoring of automatic change-over equipment has already proved acceptable.

Substation Spacing

A major factor affecting substation spacing is the drop in voltage which can be tolerated at the trains. Expressed as a percentage of the nominal voltage, this may be taken to be not more than about 20 per cent under normal conditions and 50 per cent for limited periods under abnormal conditions. The latter applies to the failure, assumed quite rare, of substation equipment or part of the supply system; the voltage drop must then be limited to a value which will keep trains moving without shutting down essential auxiliaries such as brake exhausters or compressors. On d.c. main line systems, where single-unit rectifier substations are in use, it will be desirable to work near these limits in order to keep the fixed costs for substations and track equipment to a minimum. Since the voltage drop is resistive it is inversely proportional to the cross-sectional area of the conductors and directly proportional to the distance between substations.

With an a.c. system the voltage drop is due mainly to the reactance, which is largely independent of conductor cross section, but directly proportional to frequency. It follows, therefore, that the cross-sectional area of the conductors may be reduced to the minimum size required for mechanical reasons with much less effect on either voltage drop or substation spacing than would be the case with d.c. systems.

Continental experience with 16⅔ c/s a.c. electrifications on lines of varied traffic density has shown that a nominal voltage of 15kV leads to such a wide substation spacing on purely technical grounds that practical considerations, such as the convenience of supply points and route topograhy, take charge rather than the consideration of voltage drop. The widespread use of this voltage for many years suggests that it is a good compromise.

If similar substation spacing is adopted for a standard-frequency system the effect of the trebled reactance must be taken into account. This can only be done by raising the voltage and not by increasing the copper cross section. The equivalent voltage at 50 c/s is about 25kV, since $(15/25)^2 \simeq 16\frac{2}{3}/50$. Under some conditions substation spacing may be governed by current density in the conductors. This will, however, be exceptional rather than the rule and does not affect the basic argument.

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(To be continued)

Supersonic Blow-Down Tunnel

A wind tunnel for intermittent running at Mach numbers up to 3·5 is to be built this year at the Woodford, Cheshire, factory of A. V. Roe and Co., Ltd. The working section is 27in by 30in, and models up to 18in long will be tested.

The operation of the tunnel can be followed with reference to the illustration. A 400 h.p. motor drives a reciprocating compressor capable of delivering at 115 lb per square inch abs. The compressed air is then cooled and the precipitated moisture removed, together with any oil from the compressors which would contaminate the drier. The latter is of the horizontal bed type containing silica gel, and contains electric heater units for regeneration of the beds. An absolute humidity of 0·01 per cent is obtained: this results in condensation-free flow at Mach 1·5 and sufficiently slight condensation at higher flows for the latent heat released not to give greater Mach number variations than would be expected in the design of a supersonic nozzle.

The storage sphere is 40ft in diameter and will contain a quantity of scrap iron in order to reduce the fall in temperature of the air during a discharge: it is calculated that 100 tons of 20*g*. steel will decrease the temperature drop during a run from 108 deg. to 45 deg. Cent. The charged sphere can be isolated to allow the plant to be opened up.

A quick-operating hydraulic plug valve is installed in the 36in duct to maintain a constant downstream pressure: choking will occur only in the valve itself. The delivery pressure is readily adjustable to suit the conditions of the test, and steady conditions are reached rapidly when a run begins. A further measure to minimise the change in temperature of the working medium is the provision of a heat exchanger, a drum 11ft in diameter and 4ft long packed with sheets of corrugated iron, which function as a heat store.

The heat exchanger is followed by a settling passage containing gauze screens and a contraction leading to the nozzle. The nozzle has parallel sides, the top and bottom being made of flexible plate ½in thick. The shape of these plates is controlled by fifty-two screw jacks at thirteen stations: a coded punched tape governs the contour continuously between those corresponding to Mach Numbers 1·6 and 3·5. The rotary solenoids driving the jacks respond in multiples of 0·002in and if any jack fails to follow up the tape stops; as an additional safeguard against damage to the flexible plate a strain gauge is provided. Downstream of the working section two hinged plates on the side walls form an adjustable convergent-divergent diffuser: by postponing the breakdown shock wave to a lower Mach number, this diffuser increases the running time by as much as 300 per cent at Mach=3·5. A subsonic diffuser with an expansion angle of 4 deg. gives an efflux velocity of about 100ft per second.

The models, which will be made of 60 ton to 100 ton steel, are spring mounted on a six component strain gauge balance. The model incidence will vary continuously through a run from zero to as much as 25 deg. and back, thus minimising the forces on the model at starting and stopping. The six outputs are continuously traced for subsequent visual checking and editing: a photo-electric trace reader then passes a number of discrete points into a Ferranti digital computer for evaluation. Pressure measurements over the model will be made with a minimum length of pipeline by use of transducers. Schlieren apparatus will also be fitted.

The time needed to charge the storage sphere from atmospheric is two hours. A run at 3·5 Mach number and a stagnation pressure of 59 lb per square inch abs. could last thirty-five seconds, needing one hour to recharge, and a run at 1·6 Mach number and 20 lb per square inch abs. lasting the same time would call for 110 minutes charging.

Vehicle Testing Station

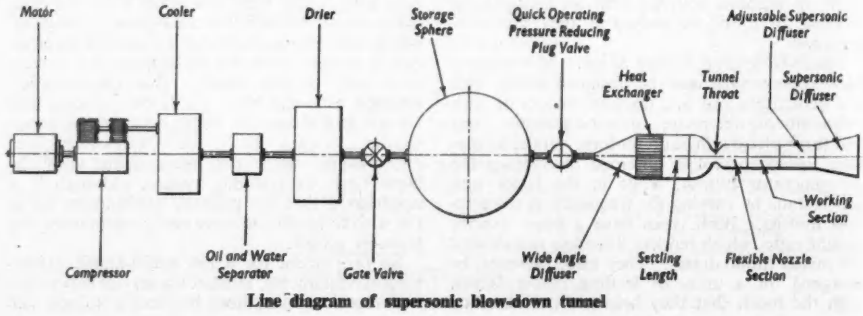
The following document was issued last week by the Ministry of Transport and Civil Aviation. Decidedly critical comment upon it appears on page 153.

Five out of every six motor vehicles examined at the Ministry of Transport and Civil Aviation's Vehicle Testing Station, Hendon, London, have faults which, in the opinion of the inspectors, should be put right before the vehicles can be considered fully roadworthy. This is one of the facts revealed by an analysis of the results of tests carried out during the period between October 11th of last year, when the station was opened, and December 31st. Altogether 6393 vehicles were tested and 5322 were found to require attention to headlights, footbrakes, steering or tyres, or more than one of these items. The results were analysed to show the main faults and the relationship between age and condition.

For cars the figures are :—

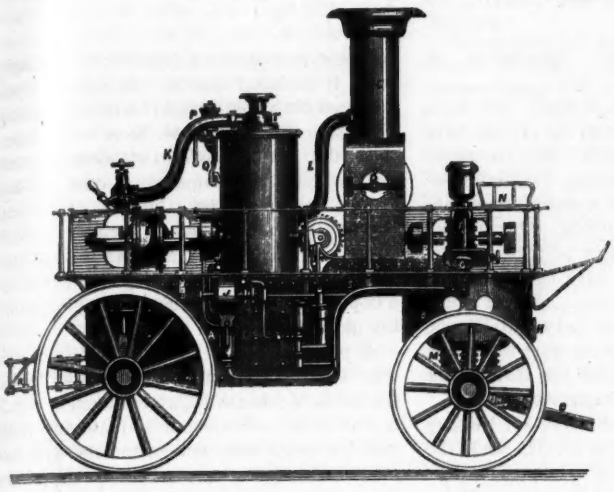
Age of car	Number tested	Number with major faults	Percentage
Pre-1945 ...	898 ...	869 ...	97
1945–1953 ...	2913 ...	2546 ...	87
Post-1953 ...	2179 ...	1675 ...	77
	5990		

Cars with wrongly aimed headlights numbered 4662, or about 80 per cent, and a third of these were post-1953 cars. Steering faults in private cars numbered over 1800. Bearing in mind that some vehicles had a number of faults in their steering, this means that one car in every four required attention. In the majority of cases the trouble was defined as excessive play in the steering mechanism. Brake troubles numbered 1551, and among the points requiring attention were brake connections, stopping power of footbrakes, and footbrake reserve travel. Tyres required attention in 368 cases. Other items tested and most frequently requiring attention were direction indicators (901), windscreen wipers (864), doors and bodywork (937), and springs (764). The number of motor-cycles tested was 261, and of these 114 had one or more of the major faults, their most common faults being connected with brakes and headlights. Tests of goods vehicles (up to 1½ tons unladen weight) showed that 118 out of a total of 142 vehicles similarly needed attention. In 113 cases the headlights were faulty, although 52 of the vehicles concerned were first registered after 1953. Many of the drivers had no suspicion that their cars were unroadworthy, and if they had not taken the precaution of having their vehicle tested they would have remained unaware of the risks they were running. Several cars had brakes which, when tested, failed altogether, others had loose steering boxes, and one had its chassis cracked in three places.

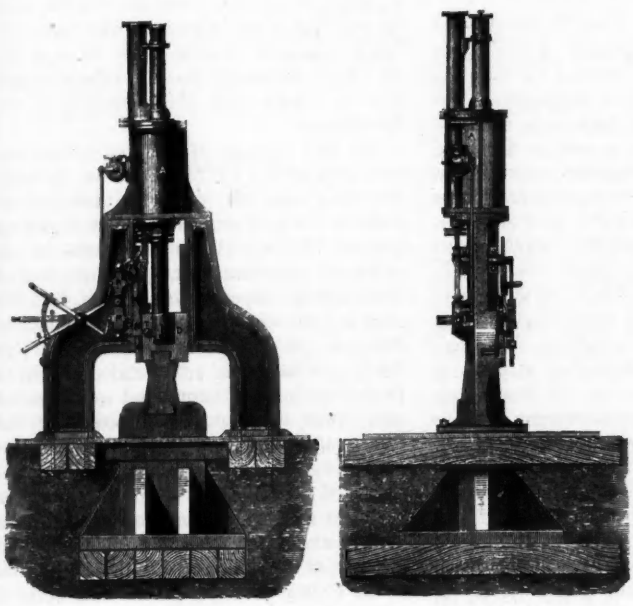


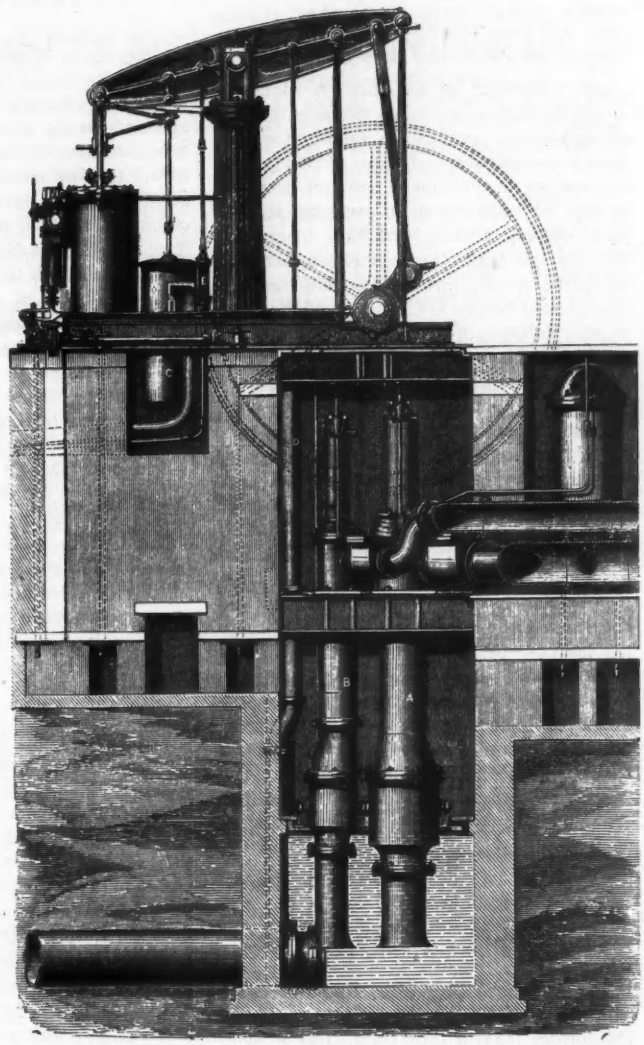
Line diagram of supersonic blow-down tunnel

Engravings of 1858



Above there is reproduced from our issue of June 11, 1858, an engraving of a steam fire engine, manufactured by Silsby, Mynderse and Co., New York. The weight of the engine was "from 4500 to 5000 pounds, with capacity to force two 1 inch streams 175ft, or 1¼in stream the same distance." The steam pressure required was "from forty to sixty pounds per square inch."

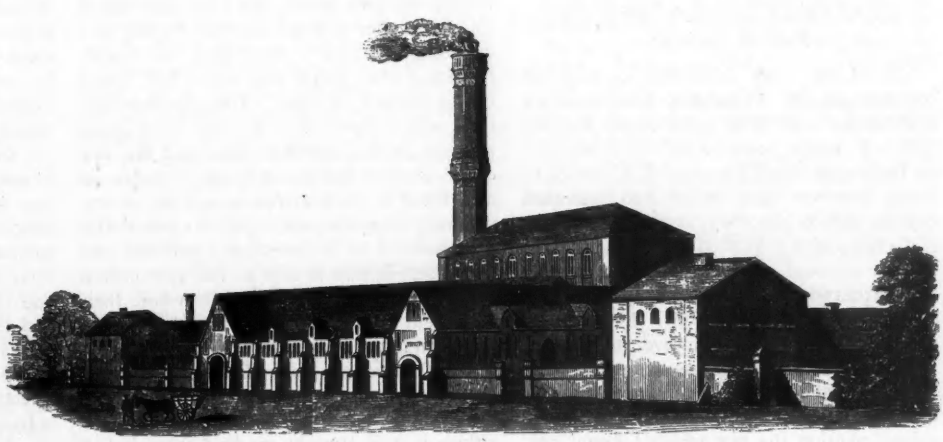




The pair of 30 h.p. high-pressure expansive condensing beam engines, built by Simpson and Co., and described on April 2, 1858, raised the water for the Crystal Palace fountains, "the most noble display of the kind." The engraving above is a front elevation of one of these engines. Each engine was "supplied with a low and high lift pump," the total delivery by the two pumps being 60,000 gallons an hour. The engines were worked by "three cylindrical boilers 22ft long, 5ft 7in diameter, with two 22in tubes in each."

The 25-cwt double-acting steam hammer, shown in the left-hand engraving, was invented by William Naylor, of Norwich. In our issue of October 1, 1858, we said that it was the "largest made on this principle." The advantages of the double-acting steam hammer for forging, it was stated, were that it could not only be worked as a single-acting hammer at any time, but the power could also be "more than doubled instantaneously and as rapidly removed."

The Berlin waterworks were described in our issue of July 2, 1858, as being "on a gigantic scale and replete with novelty." The population of Berlin at the time was 420,000. This engraving illustrates the principal station on the "Strawaler-road, in the right bank of the river Spree." The buildings shown housed the engines and boilers. They contained eight high-pressure expansive condensing beam engines, worked by twelve Cornish boilers. Four of the engines were of 120 h.p., for supplying the filter basins, and four of 150 h.p. for the high lift, "the eight being of an aggregate power of 1,080 horses."



LETTERS AND LITERATURE

A NEW INSTITUTION

SIR,—Whether or not there is room for a new institution to absorb the large number of technicians unlikely to qualify for corporate membership of one of the senior engineering institutions, I am not prepared to say, but what does surprise me is, that your correspondent, Mr. Ball, in putting forward this suggestion, should suggest that one of the qualifications for associate membership should be the G.C.E., one of the compulsory subjects of which should be Latin.

Surely, this would defeat the object in view since, unless I am very much out of touch with modern education, boys who intend going in for engineering do not take Latin at school, unless they hope to go to Cambridge, where I believe the subject is still compulsory. In any case there is a large number of young men who have obtained either the Ordinary or Higher National Certificate who would be excluded from membership owing to the fact they did not learn Latin at school. I do not decry the teaching of Latin, but I feel that some other subject, such as Physics or Chemistry, would be of much greater value to the potential engineer. In view of the great dearth of technologists at the present moment which will be aggravated in the next few years, unless there is a sudden slump in our economy, it is a question of choosing between what is desirable and what is essential.

J. F. PERRIN
A.M.I.E.E.

Carlisle,
January 22nd.

SIR,—Having read Mr. Graham Ball's letter to you on the desirability of a new Institution, I am a little puzzled as to why Latin should be one of the two compulsory subjects in the G.C.E. "O" level examination. English language certainly, but I would have thought that Maths. would also be a "must" for engineers. As regards Latin, I believe one can qualify for membership of the senior Engineering Institutions at a number of Universities without having any knowledge of Latin.

J. A. WALTERS

Sutton Coldfield,
January 25th.

CHANGING CHARACTERS OF INSTITUTIONS

SIR,—I was very interested to read the editorial on the "Changing Characters of Institutions" in your issue dated January 20th. It would seem to be inevitable that an Institution which was originally formed to bring members into social and technical contact should leave behind its objects when it develops into a qualifying body and takes part in national and international affairs, a change that you point out has happened in the case of the major institutions. I would like to draw your attention, however, to the fact that there are a few associations which have been in existence for many years and which have not lost their original purpose, and I would mention the one which I know intimately—the Manchester Association of Engineers.

This Association was formed 100 years ago and during that period its objects have remained almost unchanged. We are proud to say that we have a history of continuous activity and we have discussed matters concerning all types of engineering. Our authors have always been authorities on their subjects and the meetings which have been held this year are typical of any year. At the president's inaugural address we had an attendance of 137; on October 18th we were the guests of the Northern Branch of the Institute of Petroleum; "The Management of Men" was attended by 126, the paper on welding 61, vibration 75, polythene 52, and the "Braking of Motor Cars" 110. We were unfortunate in the weather in the case of the papers on welding and polythene as we suffered from snow and ice on the first occasion and thick fog on the second, but, in spite of these difficulties we can show an average attendance of ninety-three, which, out of a total membership of only 640, is surprisingly high and is 15 per cent of our membership.

Our membership is open to all genuine engineers and the necessary qualifications are set out in the rules. Because our members come from all walks of engineering our papers are deliberately kept to a standard which, although high, is not so technical that, say, an electrical engineer cannot follow and take full part in the discussion on a paper on mechanical engineering or civil engineering, and during each syllabus, which covers meetings approximately every two weeks between October and March, we attempt to have papers on as many types of engineering as possible. I have been told by more than one of our members that they attend our meetings and take part in the discussions because they are learning something which is of interest and which is outside their normal work.

Our meetings, whilst following a formal routine, are completely informal and our authors are given a free hand to present their papers in the way in which they wish and also to illustrate their paper by way of lantern slides, films, drawings or blackboard. Delivery of the paper, which we prefer in an informal manner and not as a set paper, usually occupies about one hour and this is followed, after a brief interval, by the discussion, which more often than not has to be closed after about one and a half hours owing to lack of time. The members say that which they have to say from their position in the meeting room and are not called on to come to the front of the room and there is no previous arranging of the speakers except in very special cases. The discussion is taken down by a reporter and each contribution is sent to the appropriate speaker for any corrections, the whole then being sent to the author to be checked before inclusion in our *Transactions*.

The *Transactions of the Manchester Association of Engineers* is an annual volume which has been issued for almost 100 years and although it is kept in modern form it has been maintained as a uniform series throughout. It contains each of the papers which has been presented together with the ensuing discussion and, so far, we have rejected any suggestion that it should carry advertisements as these quickly become out-of-date and are, in the opinion of the Council, of no real benefit to the individual member. Each paper is printed in advance and is circulated to those of our members who have asked for a copy and the cost of the printing is becoming more and more of a burden.

A point which is much in our favour is that although our members are entitled to the suffix M.Man.A.E., an entitlement which is little used, we are not a qualifying body and we only have new members who are interested in joining for the sake of the Association itself and who are interested in the benefits which can be derived from social meetings and the points of interest and importance to engineers which are brought out by free discussion. Each applicant for membership has to be proposed and seconded by a member, from personal knowledge, and it is a most pleasing and significant point that although our activities are all local we have on our lists many members who have left the district, and, in some cases, the country, who have continued their membership and kept in touch with the activities of the Association.

The first meeting of the Association was held on January 14, 1856, and we are busy preparing for our centenary celebrations which are to take place in the week beginning October 7th next. During that week we are to have a civic reception, a banquet, two or three special papers, works visits, and we shall end the week with a conversazione and dance at the College of Technology. This function is normally an annual one held in December and is a happy and well-attended one, when, through the courtesy of the Principal of the College, we are able to inspect the workings of the various departments of the College. Demonstrations are arranged and exhibitions are staged for the benefit and interest of our members and guests. Our relations with the authorities at the College are very cordial and we have always been closely connected both in an educational manner and in a social manner. An example of this is that the late Dr. J. H. Reynolds, when Principal of the College, prepared an historical record of the development of the College of Technology, in which he commented on the origin of the day instruction scheme for engineering apprentices in the following words:—

"In 1903 an important step was taken in conjunction with the Manchester Association of Engineers in the provision of day instruction for engineers' apprentices. Seventeen engineering firms responded and sent forty apprentices of seventeen years of age and upwards. The firms paid their wages, and in some cases the fee of 30s. for forty weeks of the session. The classes were held on Mondays from 9.15 a.m. until 6.00 p.m. Eventually a two-year course was provided."

In addition to the conversazione and dance we have one other social function—the

dinner and dance which takes place at an hotel in March each year. This is our occasion for returning courtesies and hospitality received from the presidents and chairmen of other societies and we endeavour to make it as pleasant an evening as possible. There are only two speeches and there is an unofficial time limit of five minutes on each !

An essential of the successful operation of our Association is an absence, wherever possible, of formality, and in achieving an informal approach one creates respect, sincere loyalty and happiness and there is no loss of dignity.

Before ending this letter I would like to comment on the very friendly atmosphere which exists between the smaller of the associations, such as the Manchester Association of Engineers, and the larger institutions, and to say that this atmosphere could be of great use to all the individual members if only it were more widely known and recognised. There is not only room for the smaller non-specialising, non-qualifying associations but there is a very real need for them. In these days of highly technical and highly specialised work it is essential for the engineer to know, whatever his particular branch, a lot about his subject and a little about every other branch of engineering.

G. M. P. McKELLEN,
Secretary,
Manchester Association
of Engineers.

Manchester,
January 25th.

TURBO BLOWERS

SIR,—Thank you for the space allowed for the review of my book " Turboblowers " in December 23rd issue, page 908, and also a previous listing in September 23rd issue. The fact itself I consider as a compliment irrespective of contents of the review, as the latter usually reflect the reviewer's background, his familiarity with the subject, his attitude and his writing manners. Incidentally, there is an obvious misunderstanding on the question of viscosity. Your reviewer apparently was thinking about the " absolute " viscosity, while in the flow processes, it is the " kinematic " viscosity that is always considered, as is clearly stated in my book. Kinematic viscosity of air is thirteen times that of water, a fact widely known by pump and blower engineers.

A. J. STEPANOFF

Phillipsburg, N.J.
January, 9th.

Literature

Land, Water and Food. By HERBERT ADDISON. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 18s.

THIS is a good book, well written and attractive. It might have had for title " The Saga of the Water," or possibly " The Romance of the Water." The author is an enthusiast of his subject and enjoys telling us about it, which explains the particular charm and colour of the narration.

The volume is primarily intended to be read by all who are interested in modern problems of world food supply, and in the relevant hydraulic developments, but are not necessarily specialists or engineers ; although even the latter will enjoy reading the book, for they are sure to find therein new approaches and original standpoints, which will stimulate their interest and attract their attention.

Throughout his long and fruitful professional life the author has held various responsible positions connected in one way or another with the problems he so vividly describes in his book, but he very wisely abstains from entering into tiresome technical details, which may have rendered the text tedious to read. The major part of his life was spent as Professor of Hydraulics at the Fouad Ist University of Cairo, but on leaving Egypt he was invited to deliver a course of lectures on " The Control of Water for Food Production " at King's College, London. A remodelled version of this course, intended for general readers, is presented in the book.

The first two chapters contain a variety of information on rainfall, river flow and the hydraulic aspects of irrigation and land development in general.

Chapters 3 to 12 are devoted to the particular problems and their solutions, characteristic of the individual conditions in each of the following countries : Great Britain, Holland, Italy, Greece, Egypt, Sudan, Algeria, Morocco, the Levant States, Iraq, India, Australia and the United States.

In the last two chapters (13 and 14) the author tells us about some of the problems of the present, e.g. the aid of the international organisations, and the problems of the future, i.e. the prospects of obtaining the required water with the help of the sea, sun, wind and atom.

The presentation is throughout clear and precise. Facts and incidents are frequently envisaged in their historic perspective.

It is suggested that Chapter 2 might have possibly gained in colour and realism had more attention been devoted therein to the modern parameters framing the inter-relation between water and agriculture, which are easily understood by the layman and convey a graphic idea of the basic points of the relevant problems. These parameters originated first in America, but were soon adopted in various other countries also, as the alphabet of the up-to-date developments in either " irrigation engineering " or " scientific farming "—whichever of these two terms the reader may prefer for designating the science (or art) of growing crops with the aid of artificial water supply. From among these various parameters the following deserve particular attention, as suitable for mention in a book of general interest : the permanent wilting point, the wilting range, the ultimate wilting point, the saturation capacity, the field capacity, the moisture equivalent, the available soil moisture, the hygroscopic coefficient, the root zone, the maximum available storage in the soil, and so on. It will be quite obvious that the use of such constants allows to assess quantitatively, by means of a simple laboratory experiment, the advantages of using a certain soil for growing a certain crop, in case irrigation water is available—and this problem, it will be realised, is very close to the main focus of interest of the entire volume. From the standpoint of agriculture, these parameters are, therefore, as important and call for as explicit an explanation, as the discharge of a river from the standpoint of hydraulics, or the evaporation and rainfall from the standpoint of climatology.

Another subject, on which more precise and specific information might have been desirable is the inter-relation between the " consumptive use of water " and the various factors on which it depends, e.g. temperature, atmospheric pressure, evapo-transpiration by native vegetation, &c.

But it is emphasised that the foregoing remarks must by no means be interpreted as adverse criticism. They rather suggest enlarging the scope and enhancing the value of Professor Addison's book, should another edition thereof be contemplated.

As it stands, the book is a valuable addition to the library of the conscientious reader, avid of acquiring genuine information on topics of foremost daily interest.

Winding Engine Calculations for the Mining Engineer. Second edition. By H. B. PRICE. London : Fraser and Chalmers Engineering Works of the General Electric Company, Ltd., Magnet House, Kingsway, W.C.2. Price 30s.

THE new edition of this book has been revised to include more details of friction winders of the Koepe and multi-rope designs. In it the complexities of winding engine design are fully discussed with particular reference to the problems of the site engineer, and an effort has been made to deal with practice both in this country and overseas.

All the winding systems at present practised are noted and a chapter on control schemes is useful in orientating the calculations to particular problems. For drum winders, calculations are given relating to cylindrical drums, bi-cylindro-conical drums and double drums ; friction winders, Koepe wheels and multi-rope winders are fully described.

In a chapter on inclined shafts the mechanics of this method of hoisting are considered and the book concludes with a chapter on calculations for steam winders. Useful tables give particulars of winding ropes and on moments of inertia for typical a.c. and d.c. motors, drums and reduction gears. The book is well illustrated and in addition to a large number of horsepower-time diagrams there are five typical arrangement drawings of winders in current use.

Arithmetic for Engineers. Fifth revised edition. By C. B. CLAPHAM. London : Chapman and Hall, 37, Essex Street, W.C.2. Price 21s.

THIS, another volume in the publishers' Directly-Useful Technical Series, was last revised in 1925, and has now been given an addendum amplifying certain passages in the text, supplying some harder examples, and introducing simultaneous equations. One of the more useful chapters covers the use of the slide rule, though unfortunately without mentioning the reciprocal scale, and an appendix deals with various verniers, including micrometers.

Books Received

Maths Made Easy. By Charles Solomon. London: Postlib Publications, Kingsbury, N.W.2. Price 10s.

Bearing Lubrication Analysis. By R. R. Slaymaker. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 40s.

Electric Motors and Controls. London : British Electrical Development Association, 2, Savoy Hill, W.C.2. Price 8s. 6d.

Steels for the User. Third edition. By R. T. Rolfe. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 45s.

Motion and Time Study. By Gerald Nadler. London : McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 56s. 6d.

Metallurgy of the Rarer Metals ; No. 4, Titanium. By A. D. McQuillan and M. K. McQuillan. London : Butterworth's Scientific Publications, 88, Kingsway, W.C.2. Price 56s.

Famous Problems and Other Monographs. By F. Klein, W. F. Sheppard, P. A. Macmahon, and L. J. Mordell. New York : Chelsea Publishing Company, 552W, 181, Street, New York, 33, N.Y. Price 3 dollars 25 cents.

AIR-CONDITIONED PAPER-LAPPING PLANT FOR HIGH VOLTAGE CABLES

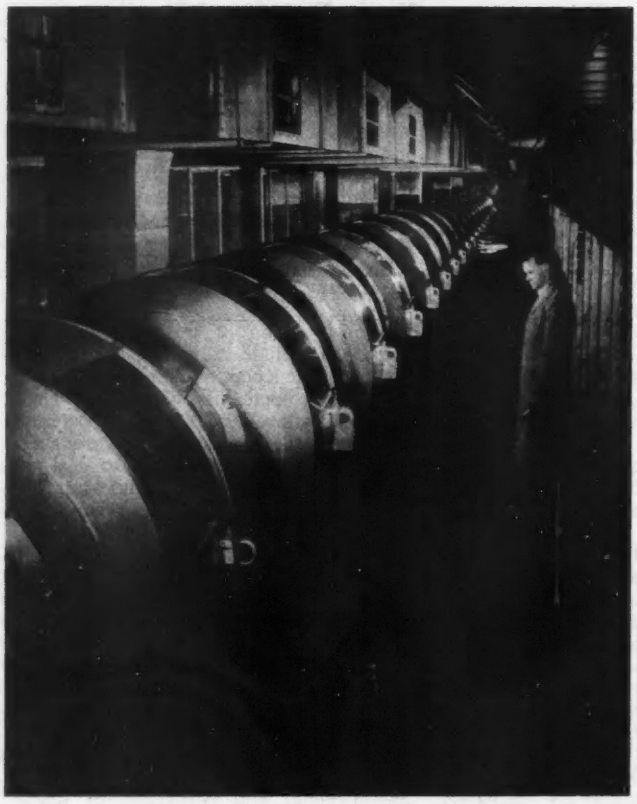


Fig. 1—Protected lapping heads of paper-lapping machine. Conditioned air enters the room through louvres (top). Behind the operator are the paper conditioning racks

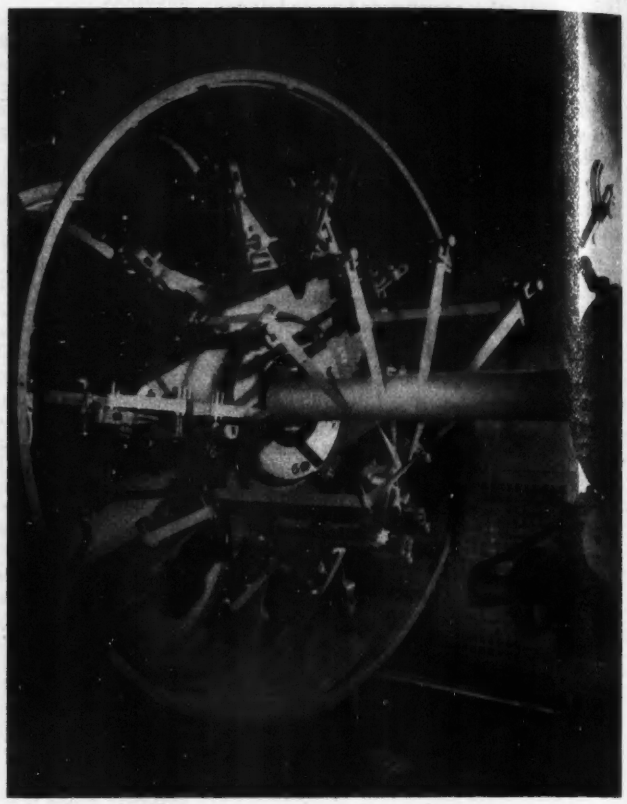


Fig. 2—Paper tapes being applied to 301kV cable by one of the twenty reversible lapping heads. Each spool of paper tape has a spring-controlled brake drum to maintain the correct lapping tension

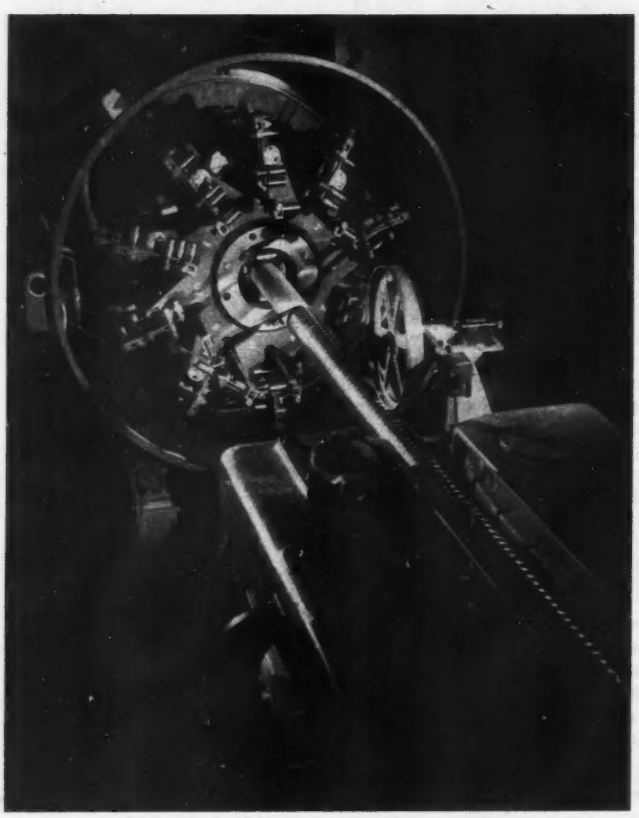


Fig. 3—Perforated foil being applied by the final lapping head. The cable is hauled off by two driven tracks made up of rubber-faced pads

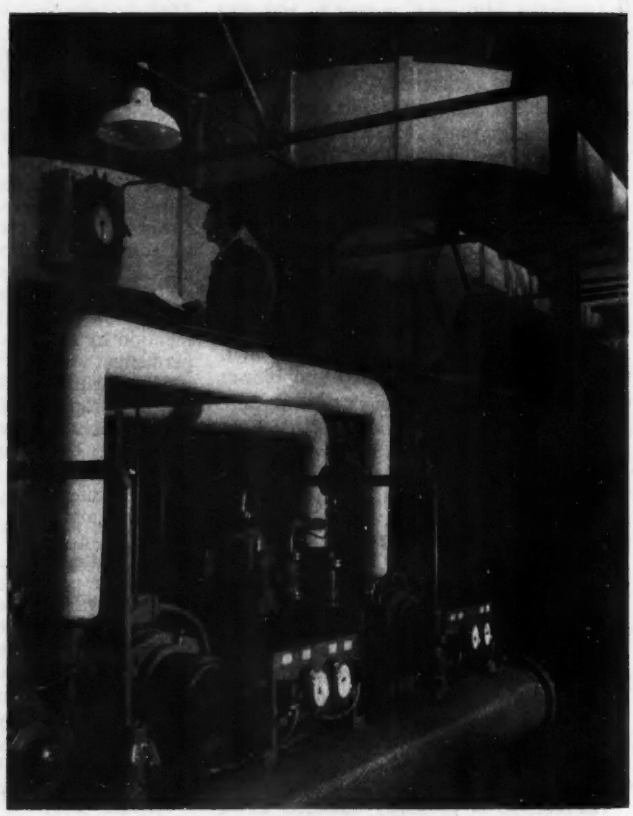


Fig. 4—Refrigerator section of air conditioning plant and ducting to and from the paper lapping machine

Paper-Lapping and Test Equipment for Oil-Filled Cables

A precision paper-lapping machine for insulating high-voltage, oil-filled cables has recently been installed to operate in an air-conditioned enclosure in the Eastleigh works of the Pirelli-General Cable Works, Ltd. The electrical development and test bays of this works have been re-equipped with test gear which includes a new impulse generator with a stored energy capacity of 38·5kW seconds and an open circuit voltage of 1600kV peak. A brief illustrated description of these equipments is given here.

IMPROVED facilities for the manufacture and testing of super-tension cables have recently been installed at the Eastleigh works of the Pirelli-General Cable Works, Ltd., an associated company of The General Electric Company, Ltd., and Pirelli, Milan. Two items of particular interest in the new installation were shown in operation last week when we visited the works. The first is a specially designed paper-lapping machine, capable of applying up to 200 layers of paper insulation simultaneously, with precise control over tension and registration. This machine operates in a fully air-conditioned enclosure so that the whole paper-lapping operation can be done in a controlled atmosphere, which implies that a consistently high standard of cable insulation can be maintained automatically. The second point of interest is that, associated with the electrical laboratory, new development and test bays have been built and equipped with impulse testing and 50 c/s high-voltage apparatus for development work and type approval tests.

Paper-Lapping Machine

The paper-lapping machine (Figs. 1—3) was devised to meet the design requirements of the Pirelli-General 301kV oil-filled cable (Fig. 5), supplied to the Aluminum Company of Canada. Until recently, the maximum permissible working stress with oil-filled cables was 90kV per centimetre. When designing 301kV cable, however, it was realised that, if the cable dimensions and the cost of manufacture were to be kept within reasonable limits, the insulation would have to withstand even higher stresses. A maximum working stress of 120kV per centimetre was considered feasible, provided that a dielectric of nearly perfect quality could be ensured. It was essential, for example, to keep the paper insulation free from wrinkles and creases—defects which reduce the impulse strength (the limiting factor in high-voltage cable design to present-day specifications).

Fig. 5—A stepped section of the Pirelli-General 301kV oil-filled cable supplied to the Aluminum Company of Canada

These defects can be avoided by very careful control of the tension with which the papers are applied, and by accurate grading of these tensions radially through the insulation. To do this, however, the moisture content of the paper at the time of lapping must be known, so that due allowance can be made for the shrinkage which occurs during drying before impregnation with oil.

Full control of the paper-lapping operation is inherent in the precision lapping machine designed and made by the Pirelli Company of Milan. The machine consists of twenty reversible lapping heads, each capable of applying ten papers, so that up to 200 layers of insulation can be applied simultaneously, to insulate cables for 300kV and above in one operation.

A fully air-conditioned chamber having a volume of 40,000 cubic feet encloses the lapping machine, together with the paper-cutting machine and storage racks for the cut paper pads, so that the paper is properly conditioned before use. The whole lapping process can thus be carried out under constant controlled conditions of temperature and humidity, 65 deg. Fah. and 40 per cent humidity in the case of the 301kV cable.

The most important part of the paper-lapping machine is the paper-tensioning device, which consists, simply, of a spring-controlled band brake acting on the pad holder. The paper passes to the cable over four rollers, one of which is attached to a pivoted lever, which is itself spring controlled and coupled by linkage to the band brake. The paper tension is predetermined by selecting springs (which are interchangeable) of the requisite strength. Two virtues of the paper-tensioning mechanism are that it is unaffected by centrifugal forces and that it maintains correct tension even when the machine is stopped and despite the slight backlash which is unavoidable.

Accurate registration of the paper tapes is controlled by means of a micrometer screw adjustment to the position of the last roller over which each paper passes, as can be seen from Fig. 2. There is also an adjustment for the angle of the paper holders to ensure that the centre plane of the paper pad is tangential to the cable; this adjustment moves all ten holders of a head together. Each of the twenty lapping heads is driven through a positive infinitely variable-speed gear, the direction of rotation being changed when required by the movement of a small leyer. The machine can be stopped or started by push button controls situated on each head. Simultaneous braking of all heads is provided by an electro-hydraulic mechanism operating through a lay shaft.

For safety in operation, all the lapping heads are partially enclosed by a transparent guard. A trip device on each head stops the machine if a paper breaks or runs out or if a guard is lifted; at the same time, a red lamp is switched on on the head affected. Cable is drawn through the machine by a haul-off, in which the cable is gripped between twin motor-driven tracks made up of rubber-faced pads (Fig. 3).

Air-Conditioning Plant

An air duct runs the full length of the paper-lapping enclosure, and conditioned air is blown from a number of outlet louvres across the top of the enclosure. After circulating, the air is extracted through apertures at floor level by a fan in the return air ducting, and is returned to the conditioning plant (Fig. 4) with a proportion of fresh outside air which is continuously added. A change of air is provided every four minutes.

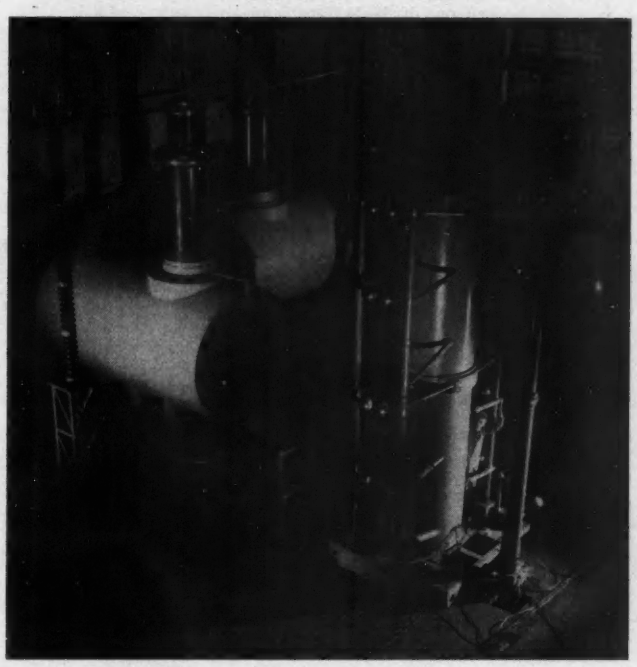


Fig. 6—The Micafil impulse generator has an open circuit voltage of 1600kV peak and stored energy of 38·5kW-sec. It can be moved on a track

Constant humidity is maintained in the conditioning plant by refrigeration units providing chilled water, which is pumped to sprays in the washer and returned to the refrigeration unit for re-chilling. In the washer, the air becomes saturated with water vapour at the low temperature. When it is subsequently warmed in the reheaters to the required temperature its relative humidity is reduced to the predetermined value. After the required temperature and humidity values have been set the whole plant is automatically controlled to maintain even conditions through summer and winter. Over a measured test period, the maximum and minimum outside temperature and relative humidity conditions varied between 34 deg. and 63 deg. Fah., with relative humidities of 48 to 84 per cent. Throughout this period conditions in the enclosure remained constant without attention at the preset values of 70 deg. Fah. and 40 per cent relative humidity.

The lapping machine take-off stands are partitioned off from the main enclosure so that cable drums can be removed and replaced without

opening the main enclosure to the outside atmosphere.

During our visit we saw the machine in operation lapping a length of 301kV oil-filled cable, which is part of a repeat order from the Aluminum Company of Canada. A stepped section of this cable is illustrated in Fig. 5. Lapping of the stranded conductor begins with the application of semi-conducting carbon-black and metallised papers, to minimise surface irregularity effects. The paper insulation has a radial thickness of 24mm, built up of papers 3½ mils thick and 18mm wide next to the conductors, followed by layers of paper 5 mils thick and 20mm wide, the outermost layers being 7½ mils thick and 22mm wide.

Although this air-conditioned paper-lapping installation was originally devised for the 301kV oil-filled cable, it can be, and is being, used for lower voltages down to 33kV. At voltages of this order, the possibilities of achieving significant reduction in overall thickness of dielectric, through precisely controlled lapping, are attractive.

Electrical Laboratory

For development and type-approval testing on very high-voltage cables, the previous test facilities were moved to a new site and new equipment added. In the development bay, a Micafil impulse generator is installed (Fig. 6), having a stored energy of 38·5kW-sec and an open circuit voltage of 1600kV peak. The generator is capable of applying impulses up to 1400kV peak on samples of cables, including accessories, up to about 25 yards in length. The impulse generator, which is of Swiss design and manufacture, is characterised by its small size in relation to its output. It is somewhat unusual in that all the capacitors are contained in a central column of bakelised paper, instead of in several porcelain columns. The capacitors are trigger discharged in series after having been charged in parallel by a charging unit which consists of a mechanical high-voltage rectifier operating at 200kV d.c.

The impulse generator is remotely controlled from a desk in an elevated control room overlooking the testing bay. Also in the control room is a cathode-ray oscillograph for monitoring and photographing the applied impulses. The control room and the entire floor of the test enclosure are screened by a wire mesh counterpoise which, with all measuring circuit screens, is earthed at a single point close to the impulse generator. The generator can be moved on rails and is provided with four operating positions, each with a separate earthing electrode.

In the development bay there are also two 330kV Ferranti transformers which can be operated either in parallel or in cascade to give a total voltage of 660kV to earth. Impulse and a.c. voltages are measured by a sphere gap between two 1m diameter copper spheres.

For routine testing of the long lengths of high-voltage cable which are now demanded, a second pair of Ferranti transformers, each having a maximum voltage of 200kV, have been installed in a second enclosure. These transformers have a combined rating of 1600kVA continuously, or 2800kVA for half an hour ; they can be operated either in parallel, at 200kV, or in cascade, at 400kV. Both transformers are provided with built-in variable reactors connected across the primary windings. The reactors are remotely controlled so that they can be adjusted to compensate for the capacitive current of the load, making possible a considerable reduction in the size of the transformers. These transformers are controlled from another desk in the main control room in which there is also a Schering bridge for power factor measurement, using an electronic detector in place of the more usual vibration galvanometer.

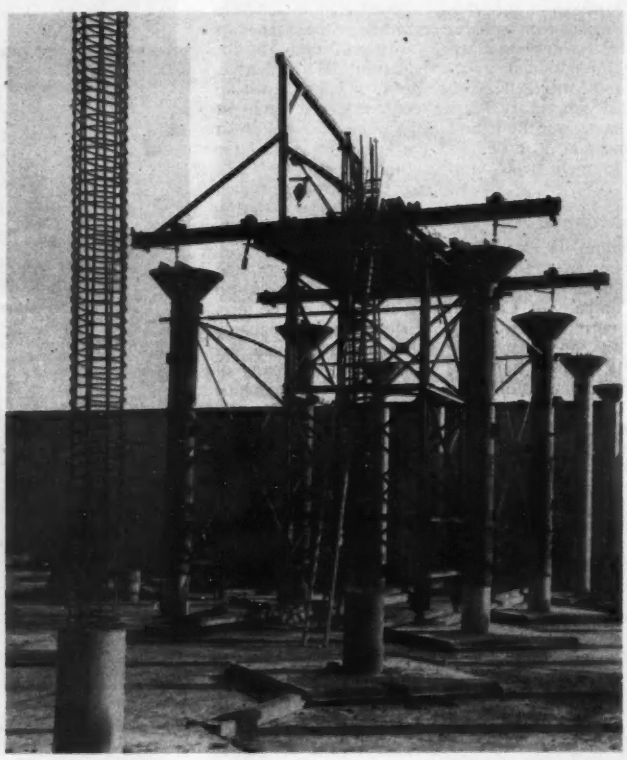
Radar Research Craft.—At the yard of R. J. Prior, at Burnham-on-Crouch, a research craft is under construction for Kelvin and Hughes, Ltd. The boat, of heavy construction, will have a length of 72ft and be powered by a six-cylinder, two-stroke Crossley diesel engine. The design incorporates the characteristics of a middle-water fishing vessel and the craft will be used for the research and development of radar, echo sounding and other scientific activities.

Annual Review of Metropolitan Water Board's New Works

PROGRESS IN CONSTRUCTION DURING 1955

Ashford Common Works.—In previous years' reviews detailed information has been given of the new filtration works, designed to afford a supply of 90 m.g.d. of filtered water, which is being constructed at Ashford Common. The main civil engineering works (contractors, John Mowlem and Co., Ltd.) were substantially completed in 1954.

Work was continued during the year on the interior finishing of the main pumping station and other buildings and on the construction of the strainer house, which will contain twenty-four micro-strainers, each 10ft in diameter and of 10ft effective length. The centre house substructure and the control chambers at the east and west wings were completed and the screening compartments were being constructed towards the centre house. Erection of the low-lift pumps



Steel moulds for forming four columns at one set-up are here shown in use at the Knockholt service reservoir

in the main pumping station, for pumping the stored water on to the filters from the Queen Mary reservoir (when gravitational flow is not possible), the low-lift pumps for delivering the filtered water into the contact tanks and the high-lift pumps for delivering the purified water into supply, was substantially completed. Pending completion of the erection of the machinery, water from the Queen Mary reservoir can be fed to all the thirty-two filter beds and temporary pumps, capable of 24 m.g.d., were connected to the filtered water outlet mains. This enables a limited quantity of water to be transferred, when required, to Kempton Park for repumping into supply.

The first illustration on page 171 shows the silencing booths for the diesel generator units under construction. The laying of heating and cable ducts was almost completed during the year and cable laying was in progress. Work was started on the roads in the filter bed area.

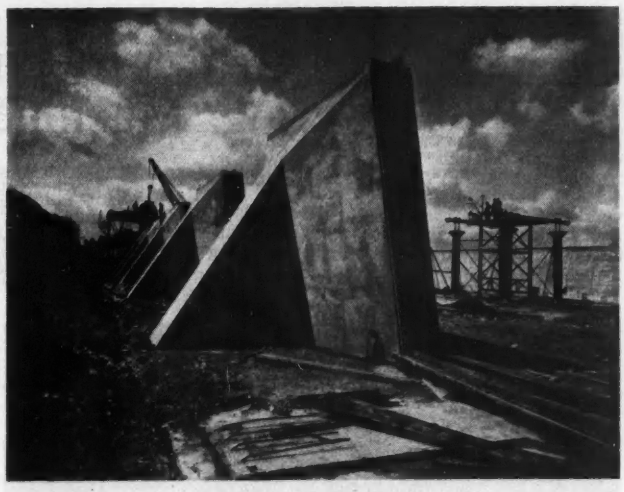
Barnes Works.—On the completion of Ashford Common the filter beds at Barnes will be abandoned and the works will be supplied with filtered water from Ashford Common, or, in emergency, from Hampton. As the water will already have been chemically treated, the larger part of the existing contact tank at Barnes will then be used for balancing, but, as the capacity will be insufficient to ensure continuity of the supply to Hammersmith if there is a temporary interruption of the supply from the Thames Valley, the Board has approved an extension of the tank to provide a greater reserve. The capacity of the new tank, or balancing reservoir, will be approximately 10½ m.g. and the total reserve, together with the supply from Barn Elms, will then be enough to maintain the supply to Hammersmith for about twelve hours. This will allow sufficient time for alternative arrangements to be made for maintaining supplies in the area served by that station.

The new balancing reservoir is to be constructed inside an existing disused open reservoir with earth banks. The existing banks will be used instead of building new walls, a new floor will be laid and the reservoir covered in. Site work was begun by the contractor, Howard Farrow, Ltd., in August, 1955. The floor and slopes were cleared and trimmed and a substantial part of the area was asphalted and concreted. Work also commenced on the construction of column footings.

Chingford South Pumping Station.—The function of this pumping station will be to lift water from the River Lee into the William Girling reservoir and the machinery will consist of five electrically driven, vertical-spindle pumps. The pumps will also be able to deliver Thames-derived water into the reservoir when the Thames-Lee tunnel scheme has been completed. Power will be obtained from the grid. The construction of the station, which is of brick-faced reinforced concrete, was completed on October 1, 1955, apart from some minor finishing items. The erection of the pumps was started and work was in progress on the laying of the pumping out mains. The principal contractors were Caffin and Co., Ltd., and William Press and Son, Ltd.

Hampton.—The laying of roads and drainage by direct labour in the area around the Sunnyside pumping station was finished and this completes the work that will be done under the original scheme for the remodelling of the Hampton works. Work was continued on the reconstruction of the slow sand filter beds by direct labour, and by the end of the year nine beds were reconstructed. Work was also in progress on the construction of further access roads to the existing filter beds to facilitate movement of sand cleaning vehicles.

Knockholt.—The first stage of the laying of mains for the improvement of supply in the Knockholt reservoir zone, consisting of 3714 yards of 18in main and 2480 yards of 12in main between



(Left) Sound insulating booths for diesel-driven alternators under construction in the machinery hall at Ashford Common works. The booths will be roofed with precast concrete elements. (Right) Knockholt service reservoir. The buttressed outer wall of the reservoir is shown under construction

the reservoir and Biggin Hill, was completed in December, 1954. A contract has been awarded to Whittaker Ellis, Ltd., for the second stage of the scheme, which includes the laying of 2800 yards of 24in main and 1200 yards of 21in main from Sundridge pumping station to the reservoir, and a 12in main from Berry's Green to Farnborough; main-laying work was due to start early this year.

The new service reservoir, when completed, will enable full advantage to be taken of the water available from the well stations south of Knockholt, and will provide a margin of safety to meet the demands for water by the growing population, particularly during peak periods. The reservoir will have a capacity of over 5 m.g. and is being constructed with mass concrete buttress walls and a reinforced concrete roof. The roof slab for about three-quarters of the roof and the whole of the columns were completed during the year. Constructional details of this work are shown in two of the accompanying illustrations. Asphalting of the roof was due to begin early this year. The contractor is John Howard and Co., Ltd.

Mains.—The laying of 3350 yards of 24in main from Caversham Avenue, Southgate, to Great Cambridge Road, Edmonton, was completed in April last. One of the more interesting of the Board's proposals from the technical point of view is the scheme for the construction of a 102in raw water main in tunnel. It has been described in the reviews of previous years and was mentioned in our civil engineering annual article three weeks ago.

A contract, awarded to Balfour Beatty and Co., Ltd., for the construction of approximately 2900ft of shield-driven tunnel with "Wedge-Block" precast concrete lining, to be driven north-eastwards from an existing shaft adjacent to the Board's West reservoir at Stoke Newington, was commenced and tunnel driving was completed last December. The driving of 4 miles of main in tunnel from a shaft at the south end of Lockwood reservoir to a point approximately ¼ mile south-west of a shaft in Dalmeny Avenue, Islington, is being undertaken by A. Waddington and Son, Ltd.; the contract was placed in April, 1955. Four shafts were sunk and work was proceeding on the sinking of two further shafts. Tunnel driving was commenced to the east and west of one of the shafts.

A further contract, for 4½ miles of main in tunnel from a point approximately ½ mile south-west of a shaft at Campden Hill works to a point approximately ¼ mile north-east of a shaft in Grafton Crescent, St. Pancras, was awarded to Kinnear Moodie and Co., Ltd., in October, 1955, and the preparatory work was begun. Orders were placed for submersible pumps required for the shaft sites at Lockwood, Stoke Newington and Barn Elms.

North-East London: Improvement of Supplies.—In the last year's review reference was made to the Board's proposals to improve the supply to this area and to meet expected future demands. The scheme, estimated to cost £455,480, includes the extension of Woodford pumping station and installation of additional machinery, a new service reservoir at Chigwell, trunk and interconnecting mains and a booster station.

The small booster station was constructed and two electrically driven pumps were installed and set to work. These pumps boost water from an 18in main into a 6in main in Vicarage Lane and enable the supply at Grange Hill, Chigwell, to be maintained.

The area of the site of the new reservoir at Chigwell is approximately 5·2 acres and the reservoir, when completed, will have a capacity of 4·8 m.g. at a top water level of 287ft above O.D. (Newlyn). It will be 18ft deep and, in accordance with the usual practice, will be divided into two halves, which can be worked independently. The contractors, W. and C. French, Ltd., started site work on June 27, 1955. The mains and drains for the reservoir were substantially completed. Work was commenced on the main walls and a considerable area of the sub-floor was concreted.

Stoke Newington.—The main structural work of a 3½ m.g. covered reinforced concrete, chemical treatment and balancing tank, low-lift pump house and building for chemical treatment was completed. Wall and floor joints of the tank were being caulked and prepared for hydraulic test. The electrical installation work was commenced. This work is being carried out in association with Messrs. Binnie, Deacon and Gourley, and the contractor is R. G. Horton (Engineers), Ltd.

Other Works.—During the year under review the remodelling schemes at Chingford Mill and Hoe Lane pumping stations were completed and work was continued at the Hammersmith and Stoke Newington pumping stations. Preparations were in hand for the remodelling of a number of the Board's other pumping stations. The roofs of the two service reservoirs at Brixton were made watertight by asphalting. The puddle walls and embankments of the East Warwick reservoir were repaired and raised by direct labour and other work was also in progress at High Maynard reservoir. The construction of Walton South reservoir was commenced in 1938 and the work was closed down on the outbreak of war. Drawings and quantities were being prepared with a view to a new contract for the construction of the reservoir being let in the spring of 1956.

A smaller work completed in 1955, but one not without technical interest, is the well station at Horton Kirby, illustrated here. The station was put up quickly in anticipation of a drought and is of a temporary character, but has been well laid out, as can be seen. It is of interest on account of its low constructional cost, and because it is unattended. There are two bore-holes and the average yield is 1½ m.g.d. (i.e. sufficient for 30,000 persons). The chlorination is automatically controlled and if the residual falls below 0·3 p.p.m. the plant shuts down. Submersible pumps are used in the bore-holes and on the surface.

Horton Kirby Well station. The station yields about 1·5 m.g.d. and is unattended

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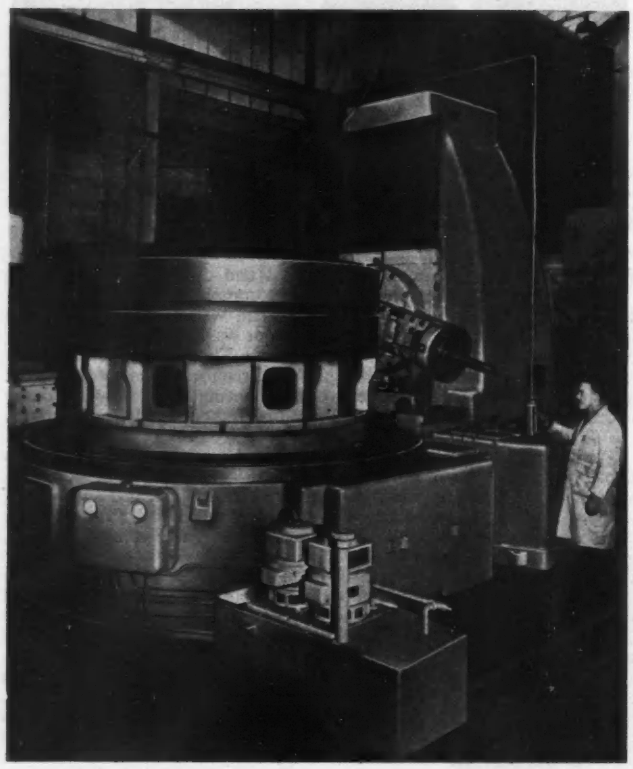
VENTILATION SYSTEM AT AUSTRALIAN ALUMINIUM PLANT.—A contract worth £80,000 for the Australian Aluminium Production Commission for supplying a complete natural ventilation system for the new aluminium producing plant at Bell Bay, Tasmania, has been completed by Hills (West Bromwich), Ltd., we are informed. The ventilating equipment supplied included opening roof ventilating shutters and adjustable louvred wall air inlet ventilators. The roof ventilating shutters comprise a series of aluminium corrugated sheets which automatically open, giving the effect of a movable roof which can be controlled according to weather conditions. The roof ventilators installed at the Tasmanian factory were made into batteries 80ft long by 7ft deep, each battery being operated by a 1 h.p. geared electric motor and controlled by a reversing contactor starter. The contract comprised over 65,000 square feet of ventilation.

Combined Gear Hobbing and Shaving Machine

A NEW dual-purpose machine for hobbing and shaving large turbine gears has been developed by the machine tool division of David Brown Industries, Ltd., Sherborne Street, Manchester. Machines of this new design are being made in four sizes capable of producing turbine gears from 60in to 175in in diameter, and pinions and first reduction wheels from 6in to 60in diameter. The use of such a dual-purpose machine not only eliminates need for a separate shaving machine, but also the time normally entailed in removing and resetting a large gear on the second machine. All that is now required is the replacement of the hob by a shaving cutter attachment.



Combined hobbing and shaving machine for turbine gears undergoing tests at maker's works. The gear is left on the table of this machine after hobbing and is then shaved by an attachment fitted in place of the hob

The four sizes of machine are built to handle gears having maximum diameters of 60in, 100in, 150in and 175in respectively, and the machines are all of similar basic design. The 150in machine illustrated on this page is capable of hobbing and shaving gears from 70in to 150in diameter with a maximum pitch of 2 D.P. and a maximum face width of 70in. It has a 133in diameter table and its index worm wheel is 120in diameter and its other principal dimensions and capacities are as follows :—

Hobbing

Maximum distance between hob and work axes	81·5in
Minimum distance between hob and work axes	30in
Maximum hob diameter	10in
Maximum hob length	12in
Range of hob speeds	19 to 64 r.p.m.
Diameter of hob spindle (driving end)	4·5in
Vertical feed (per revolution of table)	0·007in to 0·070in
Power infeed (per revolution of table)	0·0125in

Shaving

Maximum shaving cutter diameter	14in
Minimum shaving diameter	8in
Maximum width	3in
Table speeds	3 to 10 r.p.m.
Range of feeds (inches per minute)	0·03in to 0·1in

All of the machines are built to conform to B.S.I. Specification 1498 : 1954, Grade A, relating to machines designed for the production of relatively heavily loaded gears with high pitch-line velocity. In designing the machines particular attention has been given to the strength and rigidity of the hob spindle slide, and extensive use has been made of profile ground and hardened gears, and also of ball and roller bearings.

The bed itself is formed by two castings which are tenoned and bolted together and dowelled. In order to ensure smooth, precise movement of the massive upright along the bed, oil is fed into large reservoirs under the upright facings. Upright movement can be effected either by hand or by motor drive and is transmitted through a large diameter screw and reduction gearing. Vertical traverse of the hob slide is effected by a lead screw of 4½in diameter, ½in pitch, which is mounted centrally between relatively narrow precision guideways.

A large conical bearing locates the hob spindle, which is 4½in diameter at the driving end, and both the spindle and outer bearings are specially designed to give maximum support to the hob arbor when using a small diameter hob in cutting a large gear. Additional steady bearings are fitted to give extra support to the hob arbor when working under particularly arduous conditions.

When the machine is required for shaving, the special attachment, shown in our second illustration, is mounted on the hob swivel slide to replace the hob. This attachment comprises a shaving cutter, mounted on a large hardened and ground spindle, which is rigidly supported in widely spaced precision taper roller bearings. The attachment is centrally located and bolted to the swivel slide.

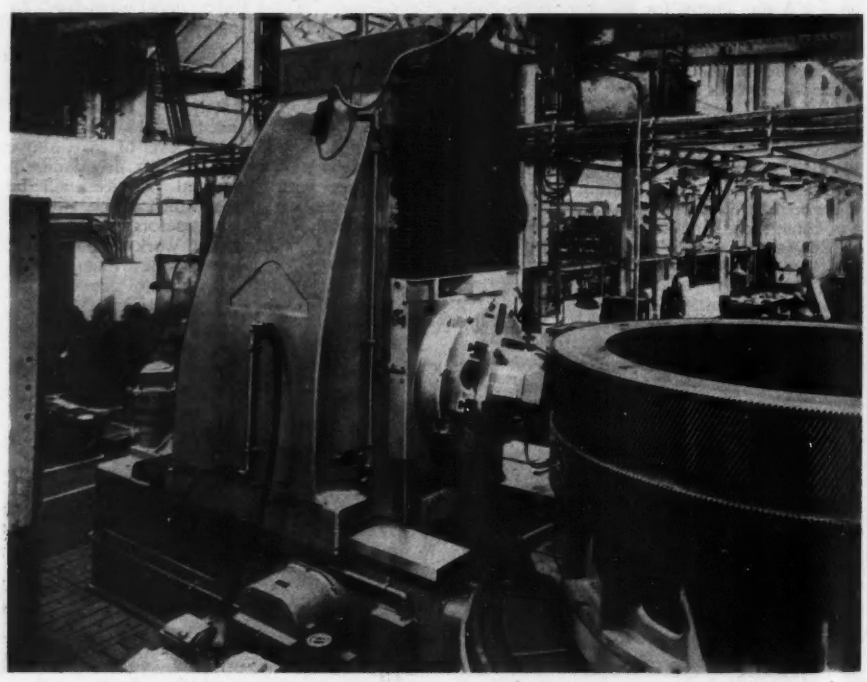
Both hand and power means are provided for swivelling the cutter to the crossed axis angle required. A brake fitted to the cutter spindle enables the tangential load method of shaving to be used if required. The loading of this brake is adjustable, and the amount of torque on the cutter spindle is registered on a calibrated scale.

A fine pitch master dividing worm wheel is provided for hobbing, and a single helical wheel for fast table rotation and for the shaving operation. The master worm wheel, which is made from special alloy phosphor-bronze, has 850 teeth and it was hobbed on a special master worm wheel generating machine. Accurately ground reference surfaces are provided on the dividing worm for the purpose of checking, which can be carried out on the machine.

To enable the dividing worm and wheel to be disengaged when the single helical drive for shaving is in operation, the worm housing is carried on a hinged bracket which permits a movement slightly in excess of the working depth. Flat annular seatings are used to locate the table axially in the bed and a recess in the seatings provides an oil reservoir through which the table load can be counterbalanced by hydraulic pressure. This pressure can be adjusted in accordance with individual gear sizes and enables constant pressure to be maintained irrespective of gear weight.

A gearbox, mounted on the side of the machine, contains change gears for the feed, spiralling, indexing and prime mechanisms. The hob drive gears which run in an oil bath are housed separately at the opposite side of the machine. An auxiliary gearbox providing suitable speeds for traversing the hob slide when shaving is built on to the end of the main gearbox. This auxiliary gearbox incorporates a variable-speed d.c. motor and worm gear drive to the feed screw shaft, which is also coupled to the hob slide rapid traverse motor. A clutch enables the shaving traverse to be disconnected when the normal quick traverse is required.

To give the comparatively high speed of table rotation needed during the shaving process, a



Large turbine gear being shaved after hobbing on the dual-purpose machine

separate motor-driven gearbox is provided. A 20 h.p. d.c. motor in this gearbox is coupled through worm and bevel gearing to the final drive single helical pinion which engages with the single helical wheel of the table unit. Speed is varied by pick-off change gears, and provision is made for low-speed running when setting up the gear blank. Electric interlocks prevent the table drive motor from being started until the master dividing worm has been disengaged from the dividing worm wheel.

A motor-driven gear pump lubricating unit, comprising two pumps mounted in tandem, supplies oil independently for the hydraulic table load relief, and to the table drive and main gearbox. A standby pump comes into action automatically in the event of a fault developing in the oil flow. The gears and bearings in the hob slide and saddle are automatically and continuously lubricated. It is not possible to start the main motor until one of the lubricating pump motors is running.

Two independent coolant circulation systems supplied by independent gear pumps are provided for the different compounds used for hobbing and shaving. The hobbing compound system has a duplicate pump which operates automatically in case of failure of the main unit.

Modern Drawing-Office Lighting Installation

AN interesting lighting scheme which is self-adjusting to compensate for daylight variations has been devised for the drawing-office housed in the new contracts office building of Mitchell Engineering, Ltd., The Bridge, Peterborough. This drawing-office forms part of a three-storey block built alongside the River Nene by the Mitchell Construction Company, Ltd., to the design of Howard V. Lobb and Partners.

Unobstructed metal-framed windows occupy the full length of the north wall to give the maximum amount of daylight in the drawing-office. To satisfy the requirements of acoustics and artificial lighting an acoustically treated ceiling, incorporating a built-in lighting system, was planned. The resulting lighting installation, as developed by The General Electric Company, Ltd., in conjunction with the architect, is reminiscent of the scheme which was originated by C. A. Parsons and Co., Ltd., for the new Parsons research and development building, as described in our issue of March 12, 1954, page 397.

In the drawing-office of the Mitchell Engineering building the ceiling is of anodised aluminium in the form of transverse rows of lighting troughs arranged side-by-side to cover the whole working area with standard 2ft square acoustic panels over the service gangway (Fig. 1). Plenum ducts forming part of the heating system are concealed behind fibrous plaster panels which divide the ceiling longitudinally into two sections.

The main characteristics of the lighting scheme in relation to the drawing board are outlined in Fig. 2. Light reaches each drawing board at angles between 10 deg. and 30 deg. from the downward vertical and most of this light comes from troughs slightly behind the overhead position. With these angles of incidence it is estimated that the possibility of specular reflection from the paper is reduced to a minimum.

A combination of hot-cathode and cold-cathode fluorescent tubes is used to provide a planned average service illumination of 75 lumens per square foot on the working plane (Fig. 3). The central section of the drawing-office is illuminated by 196 " new warm white " cold-cathode tubes housed in perforated aluminium ceiling troughs, each of which is 17ft in length and 18in in width. Each trough houses two tubes placed end to end. The use of turn-back electrodes at the junction gives the tubes the appearance of forming one continuous light source. The shadow effect at the tube ends is stated to be negligible. At one end of each trough the electrode is passed through a slot into the ceiling void, where it is connected to a transformer.

The section of the office adjoining the windows is illuminated by 100, 5ft Osram 80W " new warm white " instant-start hot-cathode fluorescent tubes, housed in similar lighting troughs. To conceal the tube electrodes and create a pleasant overall appearance, each lampholder is fitted with a spun aluminium lamp end shield, finished to match the reflectors. In addition, the troughs near the windows incorporate a supplementary heating system designed to compensate for some of the structural heat losses which occur there. The lighting troughs, which act as efficient emitters of radiant heat, are attached to the grid of pipes by means of U-section aluminium channels through which hot water circulates. A 1½in layer of glass fibre is installed over the hot water pipes to provide heat insulation and sound absorption.

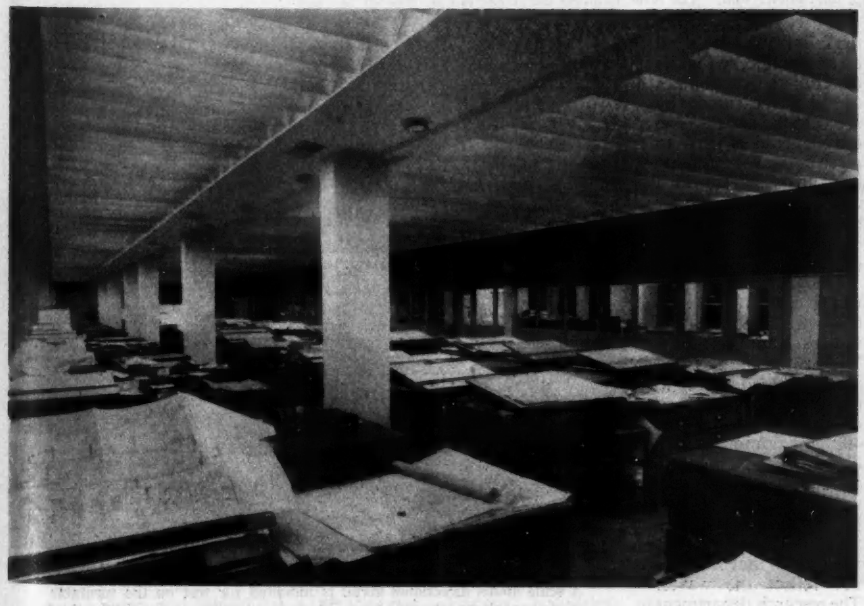


Fig. 1—A combination of hot-cathode and cold-cathode fluorescent tubes in a troughed ceiling provides artificial lighting in the drawing-offices of Mitchell Engineering, Ltd.

Transformers for the cold-cathode fluorescent tubes are housed in the ceiling void above the flat acoustic panels on the south side of the drawing-office ; each transformer supplies four tubes. Access panels are situated near each transformer position.

Instant-start control gear for the 5ft, 80W, hot-cathode, fluorescent tubes is secured to special frames situated in the ceiling void next

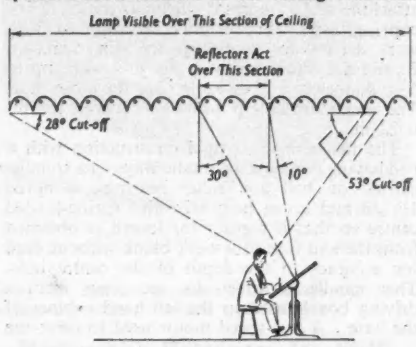


Fig. 2—Diagram showing troughed ceiling reflectors with fluorescent tube lighting, in relation to the draughtsman and the drawing board

to the windows. The frames are designed to carry two or four sets of twin lamp gear, according to the circuit arrangements. Being close to the heated troughs the control gear had to be made capable of withstanding temperatures of about 95 deg. Fah. Access panels are provided for the hot-cathode control gear similar to those for the transformers.

The whole lighting system in the drawing-office is controlled during daylight hours by two

Fig. 3—An average surface illumination of 75 lumens per square foot is produced, without shadows, on the working plane

G.E.C. photo-electric cell units which are installed on the roof, and operate through the main contactors. The units face northwards and each is set to regulate automatically a separate section of the lighting when a predetermined low level of daylight is reached. As the daylight fades, the lighting remote from the windows is switched on ; at a lower level of daylight illumination, the lighting nearest the windows is switched on. When the daylight improves the lighting installation is automatically switched off in the reverse sequence.

The drawing-office ceiling was manufactured and erected by Frenger Ceilings, Ltd., the main heating contractor was Rosser and Russell, Ltd., and the electrical installation was done by Barlow and Young, Ltd.

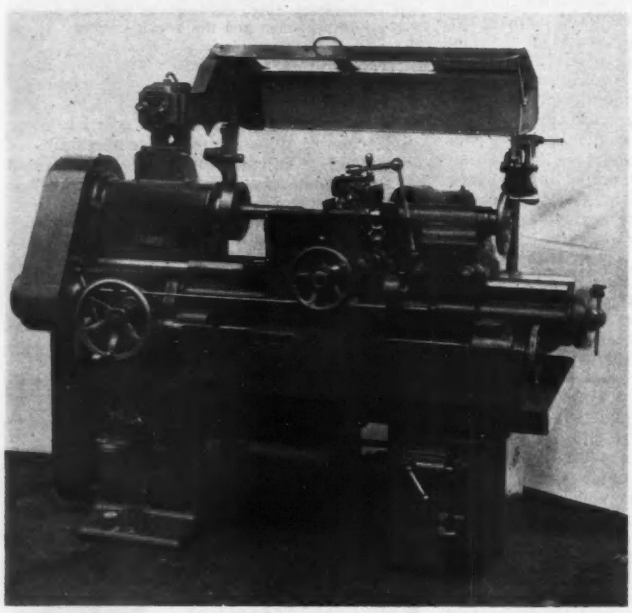
Copy Turning Lathe

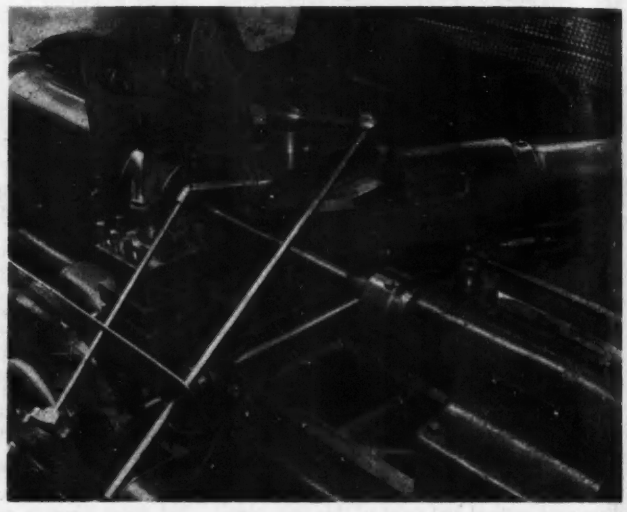
A NEW high-speed copy turning lathe, known as the "Carbijunior," is being made by Alfred Herbert, Ltd., Coventry, and it is illustrated on this page. It is basically a centre lathe so that it can be used to produce its own master components for subsequent batch production; or, if required, it can be supplied without the copying attachment for normal turning duties. For copying work the machine is supplied with work drivers for work up to 3½in diameter. Its normal centre height is 7in and work up to 5¼in diameter can be swung over the cross slide. The maximum length admitted between centres is 22½in.

The machine is of rigid construction with a bed having hardened prismatic ways. Its spindle, carried on ball and roller bearings, is bored $1^{17}/_{32}$in and it can be fitted with a spring-loaded centre so that a register for length is obtained from the end face of a work blank without need for accuracy in the depth of the centre hole. This spindle is driven by vee ropes from a driving box housed in the left-hand cabinet of the base. A two-speed motor used to drive the machine develops 9 h.p. at 1500 r.p.m. and 2 h.p. at 500 r.p.m. The drive box is directly connected to the motor and, through pick-off gears and the two-speed motor, eighteen spindle speeds from 150 r.p.m. to 3025 r.p.m. are available in two ranges. The switchgear is enclosed in the right-hand cabinet of the machine and in addition to the two push buttons for the two-speed motor there is a third button which can be used for stopping the motor almost instantaneously.

A feed-box gives three rates of automatic feed of 70, 105 and 140 cuts per inch of the saddle towards the headstock, and a quick traverse motion of 200in per minute in each direction is provided by a separate reversible motor. Four adjustable barrel stops are provided for cross slide movements in each direction, and there are six adjustable stops on a rotating bar for longitudinal movement control.

The copying mechanism consists of an auxiliary rear tool slide, a work model carrier mounted on brackets, a retraction mechanism and an independent hydraulic pump unit. The copying slide is mounted in the back of the cross slide in place of the rear tool post. Its lower slide is set at an angle to the axis of the machine and carries a movable upper slide. A hydraulic cylinder behind, and controlling movement of, the upper slide is actuated by a control valve. This valve is operated by a swinging arm carrying a tipped stylus in contact with the master component or template. The upper slide also carries a tool block which can be adjusted in relation to the work by means of a shaft extension to a fluted handle at the front of the machine. A lever extended forwards to the front of the saddle controls the retraction mechanism, which is connected to the tracer valve by cable. The retraction unit over-rides the stylus control and through it the operator can return the auxiliary slide to its fully retracted position if required. The maker states that with this copying attachment square shoulders, tapers, or any form which does not involve too high a rate of infeed can be produced automatically.





Copy turning lathe with 7in high centres and for copy turning work up to 31in diameter. Eighteen spindle speeds from 150 to 3025 r.p.m. and three sliding feeds of 70, 105 and 140 cuts per inch are available. (Right) Copying slide and controls. A shaft with fluted handle adjusts the copying tool block with reference to a micrometer dial. The lever controls the retraction mechanism

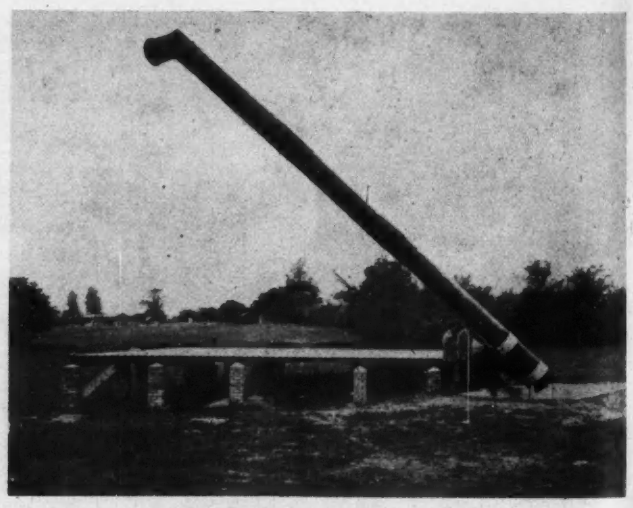
40ft Tubular Plastic Structure for Radio Research

ONE of the aims of the research work on aerials carried out by the Marconi Wireless and Telegraph Company, Ltd., is to improve the properties of directional aerials. Scaled-down models are used to find out how well the aerials beam the power in the required direction at a permanent test site, illustrated at the foot of the page. An aerial array is constructed about one-thirtieth of the full size and mounted on a turntable, so that its directional capabilities can be measured by rotating the aerial. The model aerial is used to receive waves coming from an oscillator, which can be raised in the air to simulate downcoming waves of various angles of elevation.

Design of the arm which carries the oscillator presented an unusual structural problem. The arm is tubular and carries a load of 100 lb (batteries, aerial and so on) at its head; it is 40ft long and 22in in diameter, and operating conditions restricted the use of any metal to the lower 4ft, with the remainder of insulating material so that it would not reflect the waves. The research department of the plastics division of Flexo Plywood Industries, Ltd., co-operated with Marconi's on the design and construction of this boom.

It was felt that Durestos, a long asbestos fibre impregnated with phenolic resin, would meet the insulation requirements and a series of tests were instituted to ensure mechanical strength. The construction was first envisaged as a lattice girder built up from Durestos angle mouldings and assembled with Epoxy resins with Durestos dowels and gusset plates at all the joints, but the problem of manufacturing in tubular form was later considered and eventually adopted. To attain the maximum mechanical strength of Durestos a curing temperature of at least 145 deg. Cent. is required, and it is also essential that not less than 24in vacuum is maintained on the moulding during the curing process (which may be from one to four hours, depending on the wall thickness of the moulding) to ensure removal of volatiles and products of condensation. Additionally some pressure, above that obtained by the vacuum process of something under one atmosphere, is desirable to ensure consolidation and elimination of voids in the resulting moulding.

These moulding conditions, temperatures, pressures and vacuums are best achieved simultaneously in an autoclave and the longest available was only about 30ft. It was therefore decided to mould the tube in two lengths of approximately 12ft, and a lower length of 16ft, which included moulding in a 4ft long steel sleeve



A scale model directional aerial is mounted for test on the turntable of the apparatus shown here. There is an oscillator in the head of the arm, which can be rotated to simulate downcoming waves of different angles of elevation

to accommodate the clamps for connecting to the oscillating mechanism. The mould for each of the three lengths consisted of 16 G. aluminium, 22in diameter, split longitudinally with shims in the joint to allow the mould to collapse for easy removal at the end of the moulding cycle.

The construction finally decided on was a wall thickness of ¼in R.A.1 Durestos, cured as described above, and subsequently wrapped with three layers of 0·027in woven glass cloth impregnated with polyester resin. The connection of the three sections was effected by wrapping layers of polyester-resin-impregnated glass cloth over the joints to an approximate maximum thickness of ½in, tapering off at 2ft on either side of the joint to avoid any sudden change in section. The connection of the short obtuse bend at the upper end was effected by mitring and wrapping as before.

Before delivery the boom was tested to 100 per cent overload (i.e. 210 lb), when a deflection of 3⅜in was observed with a permanent set of ⅛in when the load was removed. The total weight was 1340 lb, of which 560 lb was accounted for by the steel sleeve in the lower portion.

Anti-Submarine Aircraft

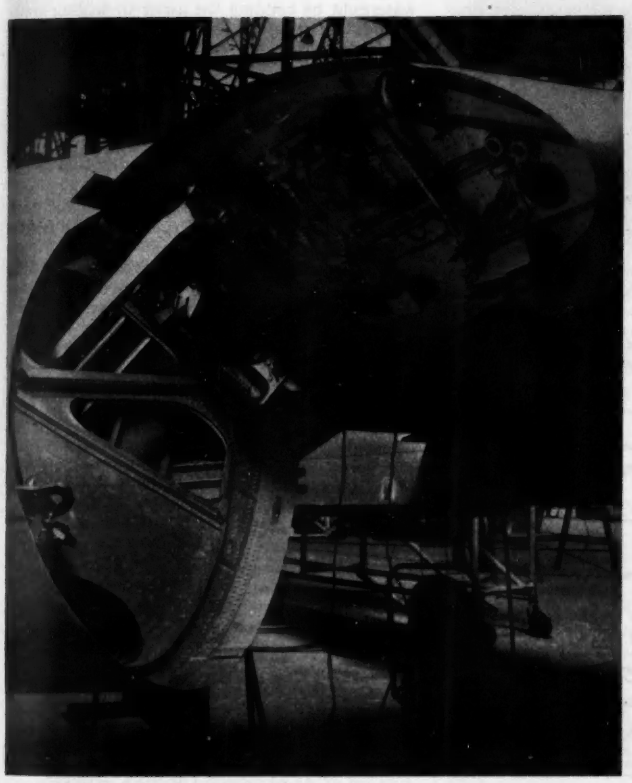
FURTHER details have now been made public of the Short "Seamew," first illustrated in these pages on September 9, 1955. Originally intended for anti-submarine and marine reconnaissance duties, the aircraft has been designed to reduce to a minimum the costs, particularly in man-hours, of manufacture and maintenance. This is reflected in the case of a fixed undercarriage of exceptionally long wheel travel, of which the main legs can be jettisoned in flight while the tail wheel is extensible for landing-on. Further to improve the chances of survival when "ditching," a watertight floor extends the whole length of the fuselage at the level of the top of the stores bay.

The Armstrong Siddeley "Mamba" engine is easily accessible by up to five men at once, and a complete power unit can be changed in an hour. Behind the engine the ASV radar is mounted in a prominent bulge, and behind it is a 14ft long bay for armament stores. Up to 2000 lb of weapons can be carried, and a hoist inside the fuselage can load depth charges and sonobuoys into the cell. Mines and torpedoes can be carried internally or rocket projectiles or fuel tanks be fitted below the wings. There is ample space for other kinds of stores which might be required for communications, customs or tribal patrol duties, and if radar is not required the enclosed space would be 17ft long.

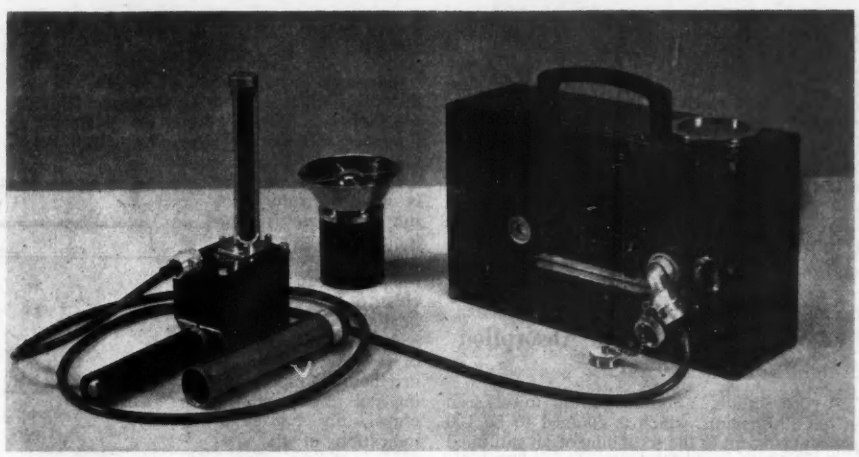
The "Seamew" can be either carrier or land based, alternative wheels being adaptable to the undercarriage; catapult launching and arrester gear hooks are fitted. At 14,000 lb all-up weight, it unsticks at 70 m.p.h., take-off distance being 250 yards, or 165 in a 15 m.p.h. head wind; 20,000ft can be reached in thirty-three minutes, and a patrol can last five hours. Maximum speed is 243 m.p.h. at sea level, and continuous rating 226, but when hunting a submarine 75 m.p.h. can be held in a turn. A dive to 375 m.p.h., is stated to be permissible.

The wing span is 55ft, reducing to 23ft when the wings are folded, the tips settling above the tailplane to make the height 15ft 9in.

Coastal Command is taking "Seamews" into service this month, and in February a "Seamew" is scheduled to make a sales tour of European and Middle Eastern countries, as well as India and Pakistan.



The wing of the "Seamew" folds to lie, leading edge down, along the side of the fuselage



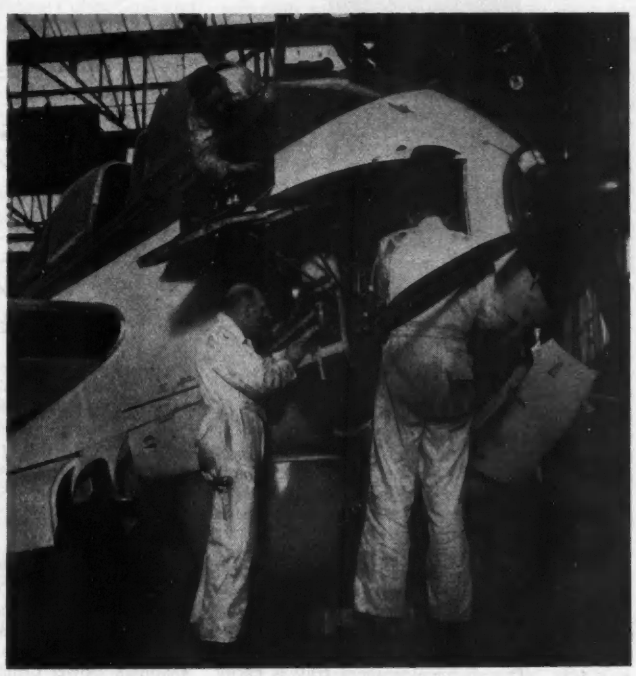
Field ratemeter for geological surveying and prospecting for radioactive ores. Field assays can be done with the help of the beta probe unit. The ratemeter uses a junction type transistor

Radioactive Ratemeter for Field Work

THE accompanying illustration shows a battery-operated instrument designed for geological surveying, mapping and prospecting for radioactive ores and for the examination of mine workings. When the instrument is used in conjunction with the associated beta probe unit assay work can be carried out in the field. The equipment, which is known as the "1368" Field Ratemeter, is made by Ericsson Telephones, Ltd., Beeston, Nottingham, who developed it in conjunction with the Atomic Energy Research Establishment, Harwell.

The ratemeter is a particle counter which incorporates a junction-type transistor and four Geiger Muller tubes. The counter rate is shown on a 50-microampere indicating meter calibrated in milli-Röntgens per hour. Count rates of 0 to 25 milli-Röntgens per hour are covered by the five ranges available in the instrument. An accuracy of either 10 per cent or 2 per cent can be chosen by operating a selector switch and the speed of response of the instrument depends on the accuracy chosen. All the power supplies are derived from three 1·5V torch cells and a stabiliser ensures that the instrument is not affected by changes in battery voltage between 4·5V and 3V.

The beta probe unit, which can be seen on the

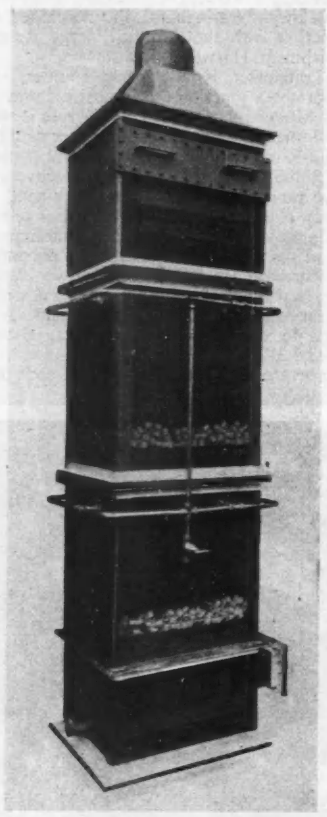


The "Mamba" is easily accessible in the nose of the "Seamew." Also visible are the "radome" and jet pipe and stores bay doors

left of the illustration, obtains its power supplies from the ratemeter through a 6ft cable. It is used for making assays of radioactive ores and for the detailed examination of rock faces and mine workings which are inaccessible to the ratemeter operator. The complete equipment, including the ratemeter, probe unit with extension handle, headphones, sample holders, filling funnel for assay work, tools, spare parts and canvas haversack, is contained in a lightweight alloy suitcase, the total weight being 28 lb. The ratemeter itself weighs 8½ lb.

Fume Scrubbing and Absorption Tower

A FUME scrubbing and absorption tower, seen in our illustration, which is claimed to be 100 per cent efficient in the scrubbing of air saturated with sulphuric and hydrochloric acid and 99·9 per cent efficient with nitric acid, has been produced by the chemical plant engineers Turner and Brown, Ltd., of Bolton. Given the name "Turbro," the tower has been specially designed for the elimination of the considerable quantities of sulphuric, hydrochloric or nitric acid fumes discharged from various chemical and industrial processes. The "S./1." unit is stated to be capable of scrubbing fumes from 14 litres to 20 litres of evaporated acid per hour. The tower, which is approximately 8ft high by 2ft square, has internal components made entirely from B.X. "Cobex" rigid vinyl acetate which is unaffected by the strongest acids and can be supplied with a special fume cabinet or as a single unit for incorporation with existing equipment.



Fume scrubbing and absorption tower

Gas removal is carried out in three stages, the first being the absorption of the greater part of the gases in liquid, after which suspended globules of moisture are eliminated in the eliminator section. Finally, any small remaining traces of gas are neutralised by a chemical reagent contained in a tray. The chemical reagent tray is easily removed for recharging, this being necessary at intervals of between ten to fourteen days, depending upon the amount of fume being scrubbed.

Long Scale Moving Coil Temperature Indicator

THE latest jet pipe temperature indicator produced by Smiths Aircraft Instruments, Ltd., Cricklewood, N.W.2, obtains an outstandingly long scale without employing gearing or linkages. On the smallest version, seen in Fig. 1, the case is only 2in in diameter, but the scale is 3½in long; a larger instrument has a scale 5½in long. It can indicate either to 800 deg. Cent. or 1000 deg. Cent., and is driven directly by four or more thermo-couples in the jet pipe; its internal resistance is 8 ohms. Fig. 2 gives an indication of the simplicity of the instrument; a symmetrical assembly of magnets and pole pieces of high quality is arranged to produce a radial magnetic field uniform over a large arc, and the moving coil is mounted so that one edge of it cuts this field. The needle represents the position of the coil, so that the possibility of backlash or friction in a transmission is eliminated. The instrument illustrated is hermetically sealed.

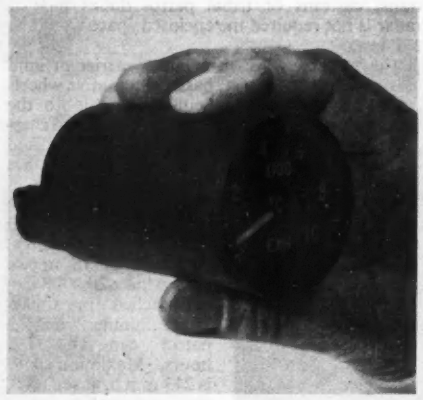


Fig. 1—This lightweight jet temperature indicator has a long and easily-read scale

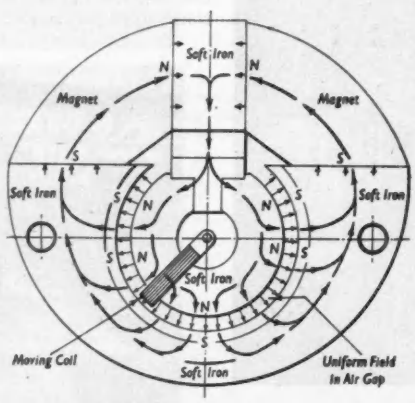
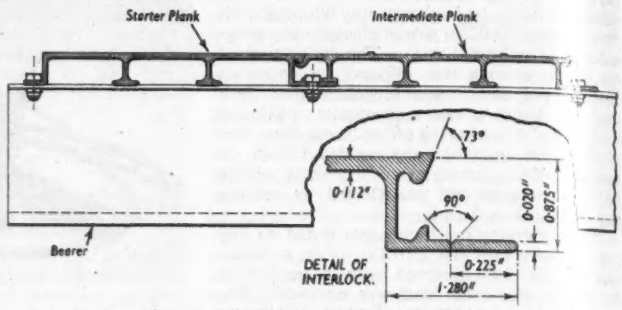


Fig. 2—The flux of two magnets is directed by pole pieces to form a long uniform field through an annular air gap

Prefabricated Vehicle Bodies

A DEMONSTRATION was recently given of the facility with which the packaged vehicle bodies produced by Bonallack and Sons, Ltd., Basildon, Essex, can be fitted to truck chassis. Using only spanners, power drills and nut runners, a small crew assembled dropside and platform bodies on bare chassis in about half a working day. These packaged bodies are both exported and supplied to vehicle distributors in this country; in the latter case, there is a marked economy in not having to bring the vehicle to the body builder and, so far as the factory is concerned, a saving in the space required for assembly. These bodies are available for the lorries of four quantity manufacturers. The assembly does not require a skilled body builder, nor is extreme precision called for, since the most part of the bolt holes are drilled in place.



Construction of interlocking platform floor of prefabricated vehicle body

An essential feature of these bodies is the "Dekaloy" floor, assembled from extruded light alloy planks running the full length of the body. This floor, while strong and hard wearing, is considerably lighter than a wood platform, and cannot absorb moisture; if required, as for carrying wet fish, the floor can be rendered watertight by bedding the joints in sealing compound. Starting at the left-hand edge of the platform each plank is laid down, interlocking with its predecessor as illustrated above. Holes are then drilled through the lip of the plank and a similar lip opposite the top flange of each bearer; the transverse location of these holes is determined by a groove along the extrusion, so that when a bolt is dropped in the hexagon is locked. This is essential, since self-locking nuts are used; the bolts and all other steel parts are coated with zinc chromate before mating with the light alloy.

Each bearer consists of a transverse light alloy channel and an assembly of pedestals resting, on wooden pads, on the chassis members; at the ends of the body, two bearers are included in each sub-assembly. The deck planks are the only longitudinals; if the body overhangs the chassis, extensions are sleeved into the side members and are welded or bolted. The rear bearer is anchored by bolts through the chassis or extension, and the remainder are held down by long bolts picking up light alloy clips on the bottom flange of the chassis. The two front bearers are built in one piece with the head board.

Chock rails run the length of the platform, and are joined to the head board by a distinctive gusset plate. They carry the hinges for drop sides and tail board, which are stiff, hollow alloy panels. Light metal wings are bolted to brackets on the bearers before and behind the rear axle. Cleats and lashing hooks do not appear.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

GENERAL REQUIREMENTS FOR THE METAL-ARC WELDING OF MEDIUM TENSILE WELDABLE STRUCTURAL STEELS TO B.S.968, TYPE "A."

No. 2642 : 1955. Price 6s. This new British standard on metal-arc welding forms one of the process standards in the comprehensive series authorised by the Welding Industry Standards Committee. It specifies the general requirements for the metal-arc welding of medium tensile weldable structural steel to B.S.968, type "a," under normal conditions of manufacture and service. Details are given of the materials to be used and the design of butt and fillet welds. Further sections deal with fabrication, qualification and testing of welding operators, supervision and inspection, and heat-treatment and testing.

Appendices give notes on butt and fillet welds, and graphs are included for the determination of intermediate values of plate thickness and varying degrees of preheat for rutile and low hydrogen electrodes for use with both butt and fillet welds.

Continental Engineering News

German Naval Developments

The building of the Federal German Navy, which is now in its beginnings, will, it is estimated, take four years to complete. As construction is limited under the Paris Treaties to warships of under 3000 tons, German naval forces will consist of smaller vessels, grouped in twenty-one squadrons. According to reports, the strength of the service will amount to some 20,000 officers and men. The future destroyers will have a displacement of 2200 tons and a complement of 250 to 280. Capable of speeds of the order of 34 knots, the destroyers will be equipped with torpedo tubes and four dual-purpose guns. No decision has so far been reached as to the guns' calibre, but depending on the rate of fire demanded, this will be between 102mm and 127mm. While the building of these ships is being undertaken some destroyers have been leased from the United States Navy.

A programme of minesweepers comprises craft of 200 tons and 400 tons displacement for coastal service, together with a larger ocean-going type of 700 tons. All these ships will be of wooden construction as a safeguard against magnetic mines. In addition there will be two minelayers of 2500 tons displacement.

Under treaty limitations, there will be no ocean-going submarines. It is stated that the permitted size of 350 tons will allow the craft to stay submerged for up to ten days. It will not be possible to equip the submarines with Walther propulsion units, and they will consequently be fitted with snorkels.

Escort vessels, of 1200 tons, will carry three dual-purpose guns and anti-submarine armament such as depth-charges. Landing craft of 350 tons will be built, and they will mount some light A.A. guns.

The first of the high-speed patrol boats was recently delivered by a German yard to the Federal coastal police force. With a displacement of about 140 tons, and powered by three diesel engines totalling 9000 h.p., the boat has a maximum speed of over 40 knots. In addition to torpedo tubes, these boats will carry twin-mounted 20mm guns.

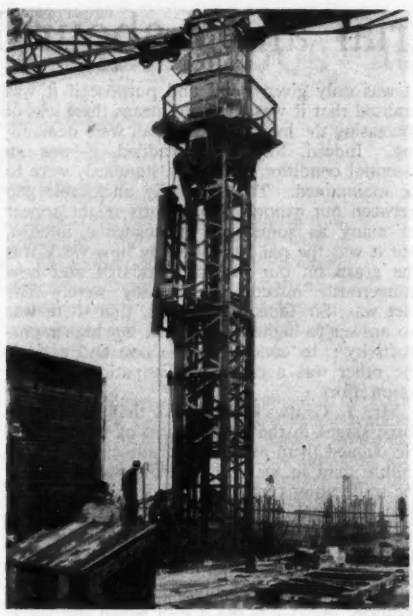
As a naval air arm, two wings of three squadrons each will be provided, consisting mainly of anti-submarine craft, close support and reconnaissance craft. In addition, there will be sea-rescue planes and other aircraft for technical purposes.

The largest ship of the German Navy will be a 4500-ton training ship, which, being not a warship in the strict sense, does not come under the treaty limitations on size. The future German Federal Navy will be based on Wilhelmshaven, Cuxhaven, Bremerhaven and Borkum on the North Sea, and Kiel, Eckernförde, Flensburg and Kappeln in the Baltic.

A Self-Erecting Tower Crane

An accompanying illustration shows the "KTK–18" climbing tower crane made by Friedrich Wilh. Schwing G.m.b.H., Dorstenerstrasse 424, Wanne-Eickel, German Federal Republic. Designed for building construction, the crane has a capacity of 1200 kg at any radius from 1·6m to 14m. It is self-erecting and carries a double hoist for concrete on its outside, consisting of two 500-litre skips. Inside the mast is a 750 kg lift for material and personnel.

When building begins the crane is set up to the height required which initially is small. It is placed within the building itself, preferably inside a lift shaft. The top of the crane comprises the jib with crab, the control cabin, the counterweight jib on which is mounted the winch, and the top boom. These parts can turn as a whole through 360 deg. They are mounted on the telescopic end section of the mast, which can be raised by an electrically driven screw spindle. When this has been done, sections can be added to the mast as illustrated, increasing the mast height by 3·40m each time. This, it is stated, can be done in five minutes. The total height of the crane can be increased to 100m or more, depending on what is required. Since the top pulleys of both the concrete hoist and the lift are mounted on the telescopic section, they are raised with it, so that the working heights of



Crane on top of building, "climbing" by another 3·4m. The telescopic end of the mast is raised and further mast sections are inserted

hoist and lift are increased at the same time as that of the crane itself. Both the lift and hoist winch are at ground level.

Lifting speed of the crane is stated to be up to 60m per minute, while maximum crab and slewing speeds are 30m per minute and 1 r.p.m. The concrete hoist and the lift both have speeds of 60m per minute. Total power consumption is 68·9kW at 220/380V, three-phase, of which 20·6kW are installed in the crane winch, while hoist and lift are rated at 18·5kW each.

Among the advantages claimed for the "KTK–18" crane are the fact that concrete hoisting can be carried out independently of the crane action, and that while the topmost storey is being concreted, the lift can be used to aid the construction at lower levels. Moreover, to position the crane within the building, in the manner described, saves using an undercarriage which, especially for cranes over 50m high, tends to be bulky, and for which space is not always available at the site. The agent for the crane in the United Kingdom is George Cohen Sons and Co., Ltd., Wood Lane, London, W.12.

Engraving and Copying Machine

The accompanying illustration (Fig. 1) shows an engraving and copying machine, which has been put on the market by Scripta Machines à Graver, 7, Passage Turquetil (Nation), Paris, 11*e*. This machine, the "Scripta S.R. 3D," is designed for milling and three-dimensional copying. Its pantograph is constructed of light aluminium alloy, all joints being fitted with ball bearings. Two thumb screws serve to lock the extending arm of the pantograph after it has been adjusted to the required ratio (between one-half and one-sixth reduction). An additional joint allows the pantograph frame to be tilted about a horizontal axis, so that the tracer and tool points can move in three dimensions, as is required, for instance, in the engraving of medals.

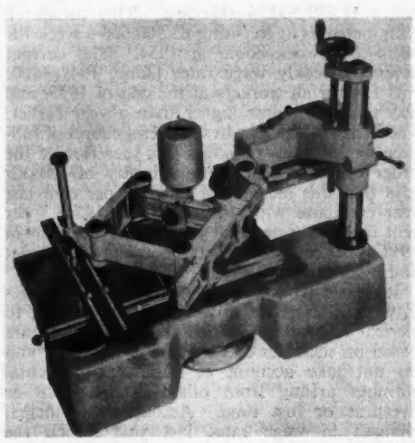


Fig. 1—Engraving machine for three-dimensional copying, shown set up for lettering

The tool spindle is directly driven by an electric motor, the speed of which can be varied between 1000 and 15,000 r.p.m. It runs in adjustable ball bearings. Tools can be of high-speed steel or carbide. For copy engraving of letters or other items of constant depth the depth is set by adjusting the micrometer screw at the tracer point.

Tables and base are made of cast iron, the tables having ground top surfaces and being vertically adjustable, the work table by micrometer. Setting lines are milled in the top of the tables, which also have a number of tapped holes for the quick location and fixing of any component. The cone supporting the pantograph is fitted with a horizontal rack and pinion slide, which permits the tool point to be moved to cover several lines without resetting of the template or workpiece. For engraving tall pieces the pantograph can be raised on its supporting column. Workpieces up to 135mm in height can thus be machined or 410mm if a specially long column is fitted. A number of attachments are available for engraving on curved or irregular surfaces, and for circular engraving. For engraving on steel a pyrographic attachment can be supplied while, for jewellery and glass, diamond points are used.

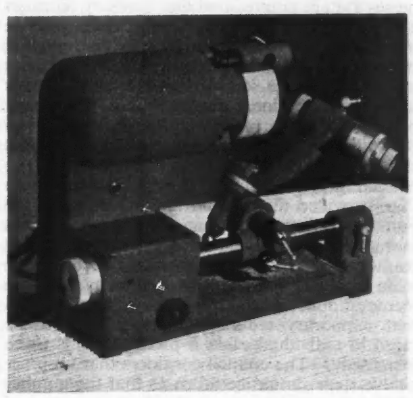


Fig. 2—Grinding machine for engraving points, with universally adjustable tool angles and micrometer feed

The same company manufactures a small tool grinder to facilitate the grinding of engraving tools to the correct shape (Fig. 2). In this machine, called the "AL.3" grinder, the dividing head is constructed to take the engraving spindle together with its cutter, which obviates centering errors. The head may be set at any angle by means of graduated vernier scales, while a graduated micrometer screw provides the feed motion. The grinder is equipped with a diamond for dressing the wheel. Agents are Acbars, Ltd., Cecil House, 57a, Holborn Viaduct, London, E.C.1.

International Congress of Automobile Technology

The Sixth International Congress of Automobile Technology is scheduled to be held in Rome at the beginning of May, 1956. The congress is held by the Fédération Internationale des Sociétés d'Ingenieures et de Techniciens de l'Automobile (FISITA), the arrangements being in the hands of Associazione Tecnica Automobile (ATA), Turin, with the support of the Consiglio Nazionale delle Ricerche. The general theme will be "Researches into Safety and Economy in Road Transport." Opening on May 3rd, the congress will continue for three days, after which there will be sightseeing tours as well as a number of visits to leading automobile motor-cycle and component factories. For full information application should be made to the Institute of the Motor Industry, 40, Queen's Gate, London, S.W.7.

Industrial and Labour Notes

British Railways Productivity Council

The British Railways Productivity Council held a meeting last Friday, under the chairmanship of Mr. J. C. L. Train, a member of the British Transport Commission. The council, it may be recalled, consists of representatives of the British Transport Commission, the three railway unions, and of the Confederation of Shipbuilding and Engineering Unions.

A statement which was issued after the meeting said that the council was devoting its attention to proposals of " general concern and application for increasing efficiency in British Railways." It was agreed that planned productivity through work study could play an important part, and the council has already examined in some detail how this planned productivity could be developed. The statement said that the council was much concerned with human relations, and was convinced that a sense of confidence throughout the staff was essential to progress. For that reason, the council was anxious that recent criticism of British Railways should not discourage and undermine the confidence of railwaymen.

In a memorandum on planned productivity, which has been circulated by the council, it is remarked that work study is twofold in its operation. First, by method improvement, management itself at all levels is subjected to a critical examination of its special functions, its weaknesses are pin-pointed and the necessary remedies are indicated. Ways of doing work can be improved, resulting in more effective use of material, plant and manpower. Secondly, it is possible to devise sound labour control systems upon which rational financial incentive bonus payments can be made on a basis which gives the staff concerned a fair share of the economies resulting from planned productivity. The council goes on to say in this memorandum that, provided there is full understanding of the human problems and of the need for appropriate incentives, planned productivity on British Railways can be to the advantage of all. The main problem is that of redundancy and the memorandum remarks that " it has to be accepted that temporary redundancy might have to be faced in individual cases if productivity is to be increased." The council considers that all practicable steps should be taken so that the number of workers becoming redundant because of planned productivity is kept to a minimum, and that where redundancy does occur everything reasonably possible should be done to avoid hardship. The council recognises that redundancy arising directly from planned productivity may have to be dealt with specially, and makes the suggestion that this question should be examined by the British Transport Commission and the trade unions through the usual channels. The council's hope is that through ordinary labour wastage, and by means of temporary suspension of recruitment and careful timing of the introduction of productivity projects, redundancy will be offset to a very material extent.

Human Implications of Work Study

On Thursday of last week, there was a meeting at Leeds to discuss the human implications of work study. It was organised jointly by the Industrial Welfare Society and the Leeds Productivity Committee.

The proceedings were opened by Sir Lincoln Evans, vice-chairman of the Iron and Steel Board, who said that the campaign for higher productivity was unfortunately clouded by many false issues and some misleading concepts. The most current, perhaps, was that which argued that it meant " working oneself out of a job." Even if that was true, Sir Lincoln continued, and experience proved it was not, to stick to old and wasteful methods in the hope that it would secure one's job was the surest way in the long run of losing one's job ! The pathetic thing about that line of reasoning was that it could create the very disaster it tried to avoid. Sir Lincoln went on to say that higher productivity as an end in itself was somewhat meaningless. It was only given point and purpose if it was realised that it was the only means there was of increasing the living standards all were demanding. Indeed, Sir Lincoln added, it was an essential condition if existing standards were to be maintained. The seemingly unclosable gap between our exports and imports might appear to many as something of academic interest, but it was the red light showing how weak was the grasp on our present standards and how dangerously insecure they really were. The fact was, Sir Lincoln observed, that there was no answer to higher real wages, but higher productivity ; to concentrate on one and exclude the other was a complete dissipation of trade union effort.

Mr. J. Gratwick suggested that there were three stages in the introduction of work study. He defined them as : the recruitment of a high calibre man to make the introduction ; taking the trade unions into the confidence of management, and making sure that there was the fullest consultation and understanding between management and employees and that employees were given necessary safeguards. Work study, Mr. Gratwick said, was suitable for any kind of business, but it was not a tool which one could pick up and put down at will. Management should face up to what work study would reveal without recrimination.

Recruitment and Training of Young Workers

When the National Joint Advisory Council met last week, under the chairmanship of the Minister of Labour, it decided to set up a subcommittee to consider the progress made, since the war, in the training of young persons for industry, and how best to deal with the problem of the " bulge " in the number of school leavers which will begin in 1957 and reach a peak in 1962. It was stated at the meeting that since the war there had been a great shortage of young workers, but now the situation was beginning to change. To-day, in some industries, notably engineering, the number of apprenticeships offered was insufficient to absorb all the suitable candidates. But in contrast to that there was the shortage of skilled workers in the main industries, suggesting that industry might not be training enough skilled workers for its needs. It was urged that the sub-committee should ascertain how various training schemes were working out in practice, form some idea as to whether the present intake of apprentices was likely to be sufficient to supply an adequate number of skilled workers in the future, and also try to estimate the effects of technological changes on training arrangements.

Changes in Wage Rates

The Ministry of Labour has estimated, from the statistics which it collects each month, that last year changes in wage rates in the United Kingdom resulted in an aggregate increase of £5,138,700 in the weekly full-time wages of about 11,889,500 workpeople. This compared with increases aggregating £3,500,600 a week for 10,147,000 workpeople in 1954. The current index of weekly wage rates (June, 1947=100) was 154 for all workers at the end of 1955, and was thus ten points higher than a year earlier. The increase last year in the average level of full-time weekly rates of wages was therefore of the order of 7 per cent. The Ministry of Labour says that this increase of about 7 per cent last year compares with 4½ per cent in 1954, 3 per cent in 1953, 6 per cent in 1952, 11 per cent in 1951, 4 per cent in 1950, and between 1½ per cent and 2 per cent in 1949.

It should be noted that the figures of changes in wage rates relate to wage-earners and not to clerical and other salaried workers. They are based on the rates of wages for a full week and do not take account of variations in actual earnings arising from other factors, such as overtime or lost time. Among the principal changes in wage rates last year which the Ministry mentions are those which occurred in the coal mining industry, iron and steel, engineering and shipbuilding, building and contracting, gas and electricity supply, and transport. In the statistics, the engineering industries are grouped under the heading " engineering, shipbuilding, electrical goods, vehicles, and metal goods not elsewhere specified." In this group, the increases last year aggregated £1,133,900 for 2,500,500 workpeople. In " transport and communications " approximately 1,136,500 workpeople received increases in wage rates aggregating £632,200 a week.

Graduates and Industry

The Federation of British Industries has addressed a letter to the Minister of Labour urging the Government to grant deferment of national service, if requested, to all science and engineering graduates with first or second class honours degrees who take up employment in industry. It is also recommended that the deferment should be continued as long as they remain in such employment.

The F.B.I. says that its grand council has been much disturbed, for some years, by the shortage of science and engineering graduates. In its letter to the Minister, the F.B.I. points out that the Government has shown its awareness of one aspect of the problem by granting deferment to graduates who go into Government or Government supported service related to the defence programme. The extent of this selective deferment, the letter continues, has increased continuously, and, since deferment can be continued up to the national service age limit, the effect in practice is that these men stay in the same sort of job and are lost to other employers for a long time, if not completely. Consequently, the F.B.I. asserts, industry's share of this highly trained manpower has become so inadequate as to jeopardise both its ancillary work for Government projects and, more important, its competitive position overseas.

The Federation acknowledges the difficulties of exempting all science and engineering graduates from national service. It is putting forward the present proposal as a means of making such men more generally available to industry.

Industrial Disputes

Last year there were 2424 stoppages of work through industrial disputes in the United Kingdom, reported to the Ministry of Labour. The aggregate number of workpeople involved in them was 670,900, and altogether about 3,794,000 working days were lost. In 1954, there were 1989 stoppages through disputes, and about 2,457,000 working days were lost.

The largest number of stoppages of work arising from industrial disputes last year occurred in the coal mining industry. They accounted for about one-third of the aggregate loss of time, and for about one-half of the total number of workers involved in all stoppages in the year, which indicates that most of coal mining stoppages were of relatively short duration. There were several stoppages of appreciable size in the vehicle building industry, which together accounted for nearly one-eighth of the aggregate loss of time in 1955. Then, of course, there were the stoppages in the transport industry ; they accounted for nearly one-half of the aggregate loss of time in 1955. The strike of locomotive men on British Railways last June, in which about 70,000 were involved, resulted in a loss of about 865,000 days, and there were about 673,000 working days lost between the end of May and the beginning of July by the strikes of 21,300 stevedores and dockers.

The Ministry of Labour figures show that the number of stoppages and of working days lost last year was the highest for many years. The Ministry says that, between 1914 and 1918, the average yearly number of days lost through stoppages was about 5,360,000, and in the three following years the average was about 49,140,000. From 1922 to 1932 (omitting 1926, when 162,000,000 working days were lost) the yearly average loss was about 7,560,000 working days. Since 1932 the annual totals have been much lower, and in the last twenty years, the yearly average has been 2,074,000 working days.

International Atomic Exposition at Cleveland

BY OUR AMERICAN EDITOR

No. III—(*Continued from page 149, January 27th*)

The first International Atomic Exposition was held at the Public Auditorium in Cleveland, Ohio, from December 10th to December 16th in conjunction with a Nuclear Engineering and Science Congress. The exhibition was organised under the sponsorship of the American Institute of Chemical Engineers and was attended by some 20,000 visitors. It presented a comprehensive picture of the current state of development in the application of atomic energy in American industry, and this article reviews certain exhibits of particular interest.

Atomic Power Development Associates

IN the American private utility industry, Atomic Power Development Associates, Incorporated, (A.P.D.A.), Detroit, Michigan, is at present probably the most active group of power companies pursuing the commercial application of nuclear energy. The group has actually commenced the construction of an atomic power reactor test facility at the Delray power station of the Detroit Edison Company. The Delray unit includes full-size parts of an atomic-fuelled electric power generating plant and will afford a full-scale operating test, without the nuclear fuel, of the key mechanical components of the liquid metal-cooled fast-neutron breeder reactor being designed by A.P.D.A. These components may be used in the actual reactor plant after the tests are completed. The components now being built include the reactor vessel, the rotating shield plug assembly, offset handling mechanism, and sodium pump. The cost of the facility has been estimated at 4·3 million dollars.

The liquid-metal-cooled fast neutron breeder reactor being designed by A.P.D.A. is to be the key component in a 100MW atomic power station which has been proposed and accepted as part of the A.E.C. power demonstration reactor programme. The A.D.P.A. reactor will operate initially on U235 fuel, not plutonium, for reasons of safety, availability of materials and lack of plutonium technology. However, it may ultimately use plutonium produced by breeding. Both the reactor core and blanket will be cooled by liquid sodium. Heat will be transferred to an intermediate sodium potassium system and then to water and steam. A heat exchanger will be used to isolate radioactive materials from the steam generator and turbo-generator. The following table lists the main data relating to the proposed plant.

Plant capacity :	
Gross electric capacity	100MW
Net electric capacity	90MW
Turbo-generator rating	100MW
Reactor specifications :	
Power (thermal)	300MW
Core diameter	30·5in
Core length	30·5in
Overall height of reactor vessel ...	156in
Outside diameter of reactor vessel	120in
Thickness of reactor vessel ...	1in to 1¼in
Core sodium flow rate	$11{\cdot}88 \times 10^6$ lb per hour
Sodium velocity	24·9ft per second
Liquid metals and steam systems :	
Net thermal efficiency	30·0 per cent
Sodium temperatures :	
Leaving reactor	800 deg. Fah.
Entering reactor	550 deg. Fah.
Sodium flow...	$13{\cdot}2 \times 10^6$ lb per hour
NaK temperatures :	
Entering boiler	750 deg. Fah.
Leaving boiler	500 deg. Fah.
NaK flow	$16{\cdot}1 \times 10^6$ lb per hour
Steam pressure	600 lb per square inch absolute
Steam temperature...	730 deg. Fah.
Steam flow	1×10^6 lb per hour
Feed water temperature...	400 deg. Fah.

The operation of this plant, together with results from the Argonne National Laboratory's experimental breeder reactor No. 2, is expected to yield information that will permit either the use of plutonium in this reactor at some future time or the construction of a full-scale plutonium breeder.

A perspective view of the reactor is shown in Fig. 8, and Fig. 7 shows the reactor core, which is an assembly of partially enriched uranium alloy pins. Plutonium is produced in the reactor core and in the surrounding breeder blanket of depleted uranium rods. The insertion of boron-containing poison rods provides shim and safety control. The core consists of numerous square fuel-element sub-assemblies arranged to approximate to a right cylinder. These sub-assemblies contain the fuel and axial blanket elements. Surrounding the core in a radial direction are sub-assemblies that contain blanket material and are the same size as the core sub-assemblies. They contain cylindrical rods of depleted uranium. Both the core and the blanket are cooled by sodium that is pumped into the bottom of the reactor vessel, flows upward through these sections and flows out near the top of the reactor vessel. By using upflow through the core and blanket, decay heat can be removed by natural circulation should this be required as a result of pump failure.

Shim control is provided by a boron control rod situated at the centre of the reactor. Very little reactivity has to be accommodated by this

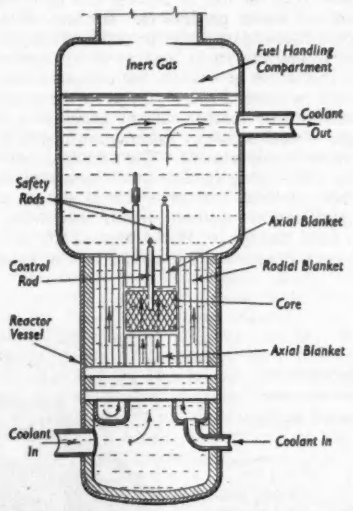


Fig. 7—Sectional view of core arrangement of A.P.D.A. fast breeder reactor

control rod, so the loss in neutrons is very small. The decision to move poison instead of fuel was made because the heat dissipation requirements are much less and because much more reactivity can be controlled per unit of volume. The control rod with this arrangement is, therefore, lighter, permitting the use of a relatively inexpensive drive. The safety or shut-down rods are also made of boron. Although these rods contain some 6 per cent Δk, they do not absorb neutrons in normal operation because, under operating conditions, they are situated out of the core at the upper edge of the top blanket. They are "scrammed" by gravity with initial spring assistance.

Unloading the core and blanket is accomplished by an element handling mechanism. It consists of a rotating shield plug and an offset handling crane mounted in the plug. A hold-down plate, suspended below the plug, maintains radial alignment of the core sub-assemblies and holds them down against the pressure drop forces caused by flow through the elements. This plate also acts as a guide for the control element drives. The sodium level is maintained approximately 11ft above the core in order to dissipate decay heat by keeping the fuel sub-assemblies under sodium during unloading and to provide natural circulation cooling of the core during unloading or on pump failure. Heat is removed from the reactor core and blanket by the circulating sodium. The heat is transferred to an intermediate sodium potassium alloy system and is then transferred to water and steam in a "once-through" steam generator.

Steam is used in a conventional steam turbine that is directly connected to an electric generator. The intermediate circuit is used to prevent a NaK-water accident from releasing radioactivity. The only items of equipment in the primary system which may require removal for inspection and repair are the pumps and the tube bundles of the heat exchangers. These are made as sump units with a free surface above the active portions and can be lifted out without cutting the piping and without draining the system. No isolating valves are used in the primary or secondary systems, since they are considered more vulnerable than the piping, heat exchanger housing and pump housing which they would be called on to isolate. The valves would also unnecessariiy increase pressure drop, and it is desirable to keep this to a minimum since the coolant flows by gravity from the reactor tank to the heat exchanger and pump. A syphon break is provided on the piping at the reactor so that a rupture in the piping will not drain the reactor tank.

Surrounding the reactor vessel is a primary shield tank which provides containment for sodium in the event of a reactor vessel leak. The large sodium pool above the reactor contains 15,000 gallons of sodium and contributes the largest part of the sixty-seven second cycle time for the sodium flow through the primary system. The pool minimises thermal shocks to the piping system which tend to accrue during a reactor "scram." Any thermal shock to parts has also been minimised by providing inlet cooling to the high pressure parts of the reactor vessel, by limiting the temperature rise through the reactor to 250 deg. Fah., by designing the top pool and piping with thin walls, and by practically eliminating the need and hence any call for "scram" action. The thermal shield composed of metal sheets is positioned against the inner wall of the reactor vessel, as shown in Fig. 8. Its purpose is to reduce the fast neutron flux reaching the reactor vessel to minimise damage from neutron embrittlement and neutron-induced thermal stress. Compartment shielding is used to provide flexibility in the design and placing of the system components. Radial shielding close to the reactor is primarily neutron shielding to reduce induced activation of the secondary coolant system. It consists of two parts, primary neutron shielding of borated graphite and secondary neutron shielding made of borax. Primary neutron shielding is situated in the primary neutron shield tank so that it can be confined and cooled by forced gas circulation. The secondary neutron shielding does not require cooling. Borax can be used as this secondary shielding because it is not exposed to high neutron flux, high temperature, or sodium.

The heat exchanger and pump machinery compartment is situated between the borax shield and the building. The purpose of the personnel shielding around this compartment is to attenuate primary gamma rays and the secondary gamma rays which are produced in the sodium. There is about 0·3 curie of radioactivity per cubic centimetre in the sodium, and it is mainly generated in the sodium pool above the core. Much of the shielding is situated outside the building, where it acts as structural support and is cheaper to construct than if it were situated inside the building.

In designing the plant, great emphasis has been placed on reactor safety. There appears to be no positive temperature coefficient of reactivity. Uranium expansion alone seems to be fast enough to handle any conceivable fast reactivity transient. The operating temperature has been chosen low enough so that, even if all of the control rods are removed, the reactor would shut off short of melting. A serious cold sodium slug accident is avoided by the low operating temperature and by the fact that the system cannot be isolated. The reactor is unloaded at temperature so that little radioactivity is required in the shim control. The number of fuel elements

has been chosen so that the maximum reactivity of one element is less than that equal to the delayed neutron fraction. Therefore, if a fuel sub-assembly were accidently dropped into the core when the reactor is critical, it would not get into a prompt period. The maximum speed of the control rods is 0·007 per cent Δk per second, so that during the start-up it cannot get into a prompt period. The fuel sub-assemblies are also inserted at this rate so that even if the core were accidentally critical during loading, the prompt period accident would be avoided.

An airtight steel cylindrical reactor building encloses the reactor, the fuel handling mechanisms, the intermediate heat exchangers and the sodium pumps, piping and storage tanks. It is approximately 84ft in diameter and has a wall thickness of about 1¼in. The purpose of this building is to contain the products of any possible reactor accident resulting in a release of fission products and radioactive sodium. All air is dehumidified and enriched in nitrogen to minimise the likelihood of a sodium-oxygen reaction should a leak occur in the liquid metal system.

Considerable flexibility has been designed into the system. All mechanisms are removable. The rotating plug is removable in layers. The control drive, rods and thimbles are removable. The fuel sub-assembly support plates can be removed, and the fuel and blanket sub-assemblies are made the same size so that they are interchangeable. Therefore, the core size can be adjusted during the initial start-up to achieve criticality. Furthermore, after a number of years of successful operation at design power, the core size can be increased to increase the power output. A full-scale mechanical test facility of the reactor and one primary loop is being constructed, and will be completed early this year. The reactor plant is expected to go into operation late in 1959. There are many design aspects of the reactor which remain to be demonstrated, but there appear to be no problems for which a solution is not foreseeable.

Because of the developmental nature of the present reactor, the conservatism in design, and the large allowances provided in estimates for capital costs, it is not anticipated that this reactor plant will be competitive with modern thermal power stations. However, it is believed that with the higher performance which will be obtained with the second and subsequent plants, coupled with lower capital costs, as a result of experience gained with this first plant, power costs competitive with present modern thermal power stations will be achieved.

Newport News Shipbuilding and Dry Dock Company

The display of the Newport News Shipbuilding and Dry Dock Company, Newport News, Virginia, at the exhibition, included a model of the S.S. "Atomic Mariner," and a model of the reactor vessel assembly for the homogeneous reactor experiment No. 2 (HRE–2) of the U.S. Atomic Energy Commission.

The "Atomic Mariner" is a conceptual design of a modern dry cargo ship powered by a pressurised water nuclear reactor similar to that installed in the submarine "Nautilus." It is an example of design studies of possible nuclear power application to the commercial marine field being made by the atomic power division of the Newport News shipyard. The vessel utilises the hull of a recent American dry cargo design, the "C4-S1A Mariner," but the principal differences in this application are the absence of boiler uptakes and stack, and the replacement of oil-fired boilers by a reactor compartment. The reactor compartment is a space, totally enclosed by shielding, which contains the reactor, the steam generators, and the necessary auxiliary equipment. Within the reactor vessel the uranium fuel, alloyed with corrosion-resisting zirconium, is arranged in a lattice of many thousands of thin rods. Water coolant under high pressure flows through this lattice, removing the heat from the fission process and carrying it to external steam generators. It there releases its heat to secondary water to produce the steam which drives the main and auxiliary turbines. From the steam generators the coolant water is returned by canned rotor pumps to the reactor. In addition to reactor, steam generators and pumps, several auxiliary systems are installed in the reactor compartment. The principal systems are the pressurising system, which maintains high pressure on the reactor coolant water, and the purification system, which maintains a very high purity in this water. The steam machinery is essentially identical to that driving a modern geared turbine cargo ship. The propeller shaft is turned by a cross-compound steam turbine through reduction gears. As auxiliaries, and for hotel services, there are the usual turbine-driven generators, distilling plants, heating systems, and refrigeration plants. The boundaries of the reactor compartment are steel bulkheads laminated with lead to form a complete shield around all sources of radiation. Because the weight of this shield detracts from the cargo capacity of the ship, a principal objective of the design is a minimum shield weight. In thickness the shield design is determined by the radiation dosage permissible for the crew. In this design the shield is as thin as possible, but still of such thickness that no crew member can be overexposed, even if he stands next to the shield for the entire voyage. In surface area the shield design is determined by the volume of machinery that it must enclose. All reactor compartment machinery is therefore arranged as compactly as feasible making allowance for access for maintenance. The resulting shield weight in the "Atomic Mariner" is much less than the weight which is saved by eliminating the need for fuel oil. Because of the present high costs of building atomic power plants, the potential advantages of nuclear propulsion have not been sufficient to make the building of an atomic ship commercially attractive. It is likely, however, that advances in nuclear science and engineering will swing the balance increasingly toward economic feasibility. Believing in this trend, the firm is continuing its design work in the nuclear propulsion field, and is in active consultation with several companies developing commercial power reactors.

Sylvania Electric Products, Incorporated

The case of Sylvania Electric Products, Incorporated, Bayside, New York, is a good example of an American manufacturer of electrical and electronic apparatus entering the field of producing fuel elements and other reactor components. To-day the firm's Atomic Energy Division is probably the largest single group in the United States employed exclusively in such work. Its resources are actively engaged in the production and development of fuel elements and fuel element materials, fuel assemblies, reactor components, such as control rods, moderators

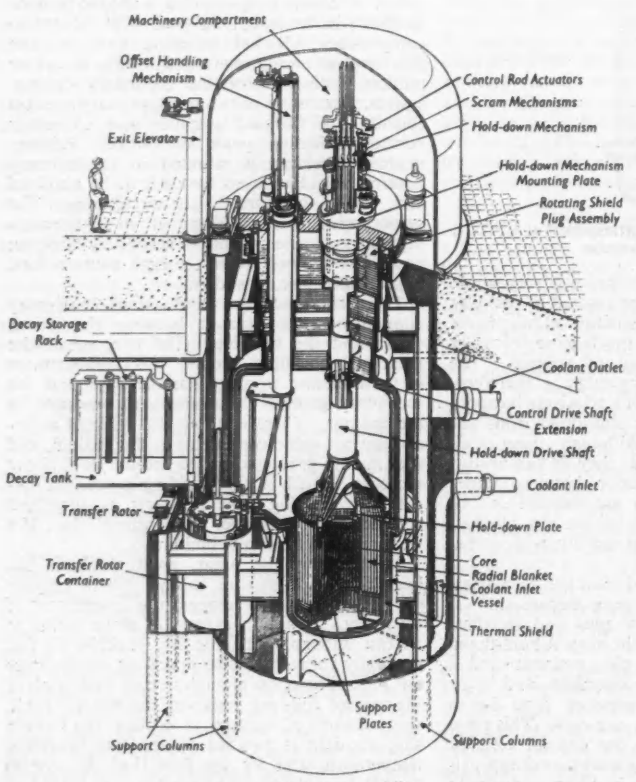


Fig. 8—Perspective view of A.P.D.A. liquid-metal-cooled fast breeder reactor with thermal capacity of 300MW

Fig. 9—Panel of reactor fuel elements manufactured and exhibited by Sylvania Electric Products

and reflectors, and a variety of reactor accessories, including pumps, control rod drives and test loops.

The division fabricates nuclear fuel elements in a wide variety of shapes and configurations, including solid and hollow slugs, rods, tubes, flat, curved and corrugated plates, wire, wafers, with and without perforation, wafer assemblies, pellets and spheres, and foil. Fig. 9 shows some of these fuel element forms which were exhibited by the firm at Cleveland.

The economic production and reprocessing of nuclear fuel is now one of the most critical factors in the ultimate attainment of competitive electric power from the atom. The Atomic Energy Division has processes under advanced development for effecting the economical recovery and refabrication of irradiated fuel elements. These processes are intended to be an integral part of the complete fuel cycle, which includes fuel element manufacture and reprocessing. Sylvania is also actively studying methods for the metallurgical refabrication of fuel elements into a new reactor charge in lieu of chemical reprocessing, as a means of reducing the equivalent nuclear fuel cost. Through the use of this knowledge in fuel reprocessing, coupled with its broad background in fuel element fabrication, the firm plans to provide a complete out-of-pile service to reactor designers, builders and operators.

Metals and Controls Corporation

An interesting collection of nuclear fuel elements and their components was exhibited by the Metals and Controls Corporation, Attleboro, Massachusetts. This firm has been engaged since 1952 in the fabrication of fuel elements and fuel element components for the U.S. Atomic Energy Commission and its contractors. A complete facility for the production of fuel elements is now in operation and is available to serve authorised concerns. Whether for small thin gauge foils for experimental application or for complete fuel assemblies, the company is prepared to meet industrial needs. Since 1916, the Metals and Controls Corporation has specialised in the production of bonded metals and has pioneered in the commercial production of new and unusual metals either as bonded composites or as fabricated pure metals. This experience has been applied to fuel element manufacture, and is now available to others in the expanding American nuclear energy programme.

Uranium, either enriched or natural, or thorium, can be rolled in kilogramme lots to gauges as thin as 0·0006in ±0·0002in. These foils can be used in research experiments such as cross-section determinations, or can be supplied clad with metals or plastics for zero power research reactors or critical experiments. The modern rolling equipment of the company consistently produces foils in precise gauges free of pin holes. Consumable and tungsten electrode arc melting facilities as well as vacuum induction melting furnaces have been developed for the preparation of alloys of uranium and thorium with zirconium, aluminium, or other metals as required. These alloys can be supplied either bare or clad with other metals or plastics for the complete fuel element or assembly. Fuel elements can be made by extrusion processes using either integral end-enclosures or co-extrusion with butt-welded end caps being subsequently attached. Extrusion of oxide and metal powder combinations for fuel elements also has been accomplished. Flat plate elements, either with alloy cores or oxide in metal cores, have been made. Fuel elements or fabricated shapes have been supplied by the firm for the Thermal Test Reactor and Submarine Intermediate Reactor at the Knolls Atomic Power Laboratory, and for critical experiments at the Oak Ridge National Laboratory, as well as for classified reactors at the Savannah River Plant, the Hanford Plant and the Argonne National Laboratory of the U.S. Atomic Energy Commission.

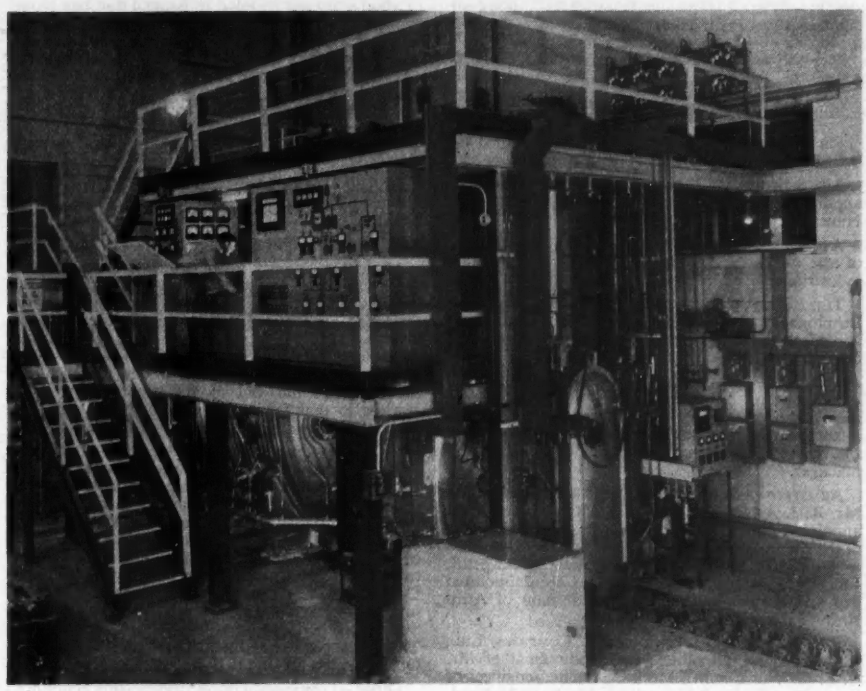


Fig. 11—2200 lb vacuum melting furnace manufactured by National Research Corporation and installed at the Syracuse works of the Vacuum Metals Corporation

Vacuum Metals Corporation

The exhibit of the Vacuum Metals Corporation, Syracuse, New York (which is jointly owned by the Crucible Steel Company of America and the National Research Corporation), stressed the firm's work in the production of high purity alloys with closely controlled composition, particularly those with reactive components. Vacuum induction furnaces with capacities from a few pounds to a ton of steel are now being operated by this concern. Arc melting units operating in vacuum or inert atmosphere with non-consumable or consumable electrodes and with cold mould or skull melting techniques, are available for the production of pilot quantities. The production operations at Syracuse, New York, are closely integrated with the production facilities of the Crucible Steel Company of America, where ingots are reduced to various forms, such as forging billets, bar, rod, wire and sheet in mills accustomed to handling high quality special steels and alloys. All melting operations are very closely controlled by the monitoring of pressure, temperature and gas composition, and pre-tapping analyses ensure close composition control. A wide range of materials is being produced, including special bearing steels, stainless steels, alloy and carbon steels, high temperature alloys and electronic instrument alloys. Among the pilot production operations carried out by the firm have been the vacuum melting and casting of uranium, thorium, chromium, lead and special light alloys. Experimental production of control and shielding materials, such as high boron steels, has been undertaken in ingot sizes up to 630 lb, and ingot sizes up to 2200 lb are now being facilitated by the largest vacuum melting furnace in the United States which is shown in Fig. 11 and which commenced operation at Syracuse in December. The new furnace is remotely operated by the melter, who can control from one console the charging, mould transfer and pouring operations. The melting unit is enclosed in a ¾in thick air-tight and liquid-cooled stainless steel chamber, with connecting air lock chambers for charging raw materials and discharging ingots. The design makes it possible to charge, melt, pour and remove ingots without affecting the vacuum in the melting chamber. The mould handling mechanism makes it possible to cast ingots of varying size and shape, either singly or in multiples from a single heat. The furnace was built by the Equipment Division of the National Research Corporation and increases by 60 to 75 tons the monthly potential supply of vacuum-melted metal in the United States.

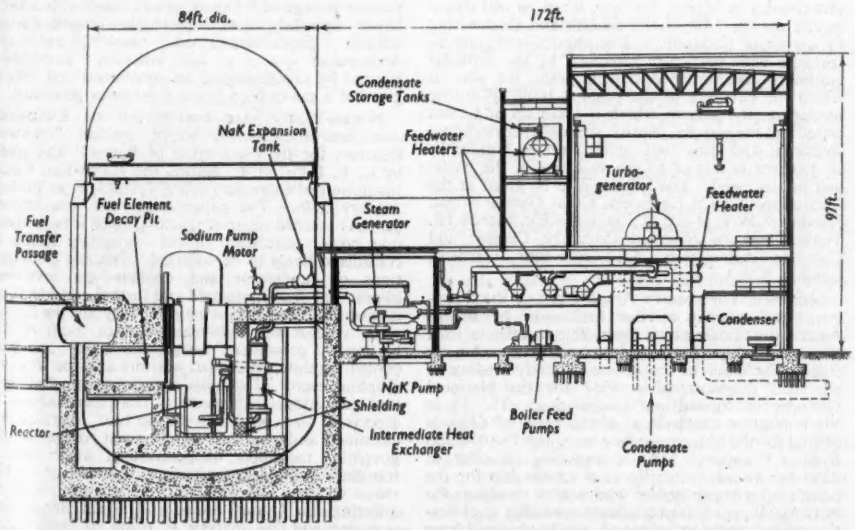


Fig. 10—Proposed general arrangement of 100MW nuclear power station for the Detroit Edison Company

(To be continued)

Personal and Business

Appointments

SIR HUGH MOLONY, Bt., M.I.C.E., has joined the board of Stewarts and Lloyds of Ireland, Ltd.

MR. B. SMITH and MR. C. E. MIDDLEMISS have been appointed directors of Clarkson (Engineers), Ltd., Nuneaton.

AUTO DIESELS, Ltd., announces the appointment of Mr. W. Hutter as home sales manager for "Stad" industrial engines.

THE PARKINSON STOVE COMPANY, Ltd., Stechford, Birmingham, 33, states that Mr. Harold F. Beaumont, M.I.Mech.E., works manager, has been appointed a director.

MAJOR-GENERAL D. C. T. SWAN has been appointed managing director of Fred Myers Tractor and Equipment Company, Ltd., in succession to Mr. A. N. Dixon, who has become vice-chairman of the company. Mr. M. R. F. Lemon has been appointed general parts manager.

ARMSTRONG SIDDELEY MOTORS, Ltd., states that Mr. R. J. Ashley and Mr. J. E. Attwood have been appointed directors. Mr. Ashley is general manager of the car and diesel engine division and Mr. Attwood is a director of Armstrong Siddeley (Brockworth), Ltd. Mr. Waldo B. Price-Owen has been appointed export manager of the motor-car division of Armstrong Siddeley Motors, Ltd.

BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., Loughborough, announces the appointment of Mr. C. L. G. Worn, A.M.I.Mech.E., as chief engineer of the turbine division. He succeeds Mr. R. C. McLeod, who has relinquished executive responsibility in order to devote all his time to technical design. Mr. L. A. Benn, A.M.I.Mech.E., has been appointed chief engineer in the heavy electrical plant department, and Mr. J. R. Hutchings has been appointed engineer-in-charge of spares and repairs (Brush Ljungstrom radial flow steam turbine).

Business Announcements

MERRYWEATHER AND SONS, Ltd., Greenwich, S.E.10, has announced the retirement of Mr. Leonard C. Miller, A.M.I.C.E., director and works manager. Mr. Miller, who has spent forty-seven years in the firm's service, has been works manager since 1938 and a member of the board since 1942.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., states that the address of its Liverpool district office is now 18, Hepworth Chambers, Church Street, Liverpool, 1 (telephone, Royal 4391). The lamp and lighting department's office remains at 27–29, Stanley Street, Liverpool, but its telephone number has been changed to Central 4371.

Contracts

BRUSH EXPORT, Ltd., Loughborough, has secured a contract valued at £140,000 for extensions to the existing diesel power plant at Cochabamba, Bolivia. The equipment to be supplied includes three National "B4AU8" pressure-charged, vertical diesel engines, each developing 1650 b.h.p. at 333 r.p.m., coupled to Brush 1150kW, three-phase, 50c/s alternators, generating at 10kV.

THE GENERAL ELECTRIC COMPANY, Ltd., has received an order from Simon-Carves, Ltd., for two 8000kW, double-pass-out condensing turbo-alternators. Installation of these sets in the carbonisation plant will form part of the modernisation which the National Coal Board is effecting at Cwm Colliery in South Wales. Inlet steam conditions of this single-cylinder turbine are 400 lb per square inch gauge, 800 deg. Fah., and the exhaust is into a vacuum of 28·0in Hg. The pass-out steam pressures are 130 lb per square inch gauge and 25 lb per square inch gauge. The maximum quantities of steam which may be passed to process are 27,480 lb per hour at the first pass-out stage, and 25,590 lb per hour at the second pass-out stage. Each of the 3000 r.p.m. alternators will have an output of 8000kW at 11kV, 0·8 power factor, and will draw its field supply from a main exciter nominally rated at 55kW. The armature of the exciter and that of the associated pilot exciter will be mounted on a common shaft which will be flexibly coupled to the alternator rotor.

Miscellanea

INFLATABLE HUT.—An inflatable hut, comprising a low-pressure inflatable framework with a rubberised fabric covering is now being made by Elliot Equipment, Ltd., Llwynypia, Rhondda, South Wales. It has a clear floor space of 30ft by 19ft, a height of 9ft, and weighs 160 lb.

VEHICLE PRODUCTION FIGURES.—The British motor industry produced 1,240,000 vehicles in 1955, more than in any previous years; cars alone numbered 900,000. The total exports exceeded £1,000,000 sterling per day for the year. Both for cars and commercial vehicles exports increased, sales to Australia and the Union of South Africa in particular rising, but trade with New Zealand, U.S.A. and Sweden declined, in the latter instance by one-half.

MEMORIAL SERVICE: SIR RICHARD REDMAYNE.—On Thursday of last week, January 26th, there was held at St. Margaret's, Westminster, a memorial service to Sir Richard Redmayne. The address was given by Mr. J. B. Fry, Chairman of the Institution of Professional Civil Servants (of which Sir Richard was President) who recounted briefly the events of Sir Richard's life and dwelt in particular on his services to that Institution and to professional civil servants as a whole during his long term of office as President.

AXIAL-FLOW BLOWERS AT MARGAM STEELWORKS.—In a paragraph entitled "Plant Extensions" in an article entitled "British Iron and Steel in 1955" (our issue of January 20th, pages 92 and 93), reference was made to turbo-blower plant at Margam works of the Steel Company of Wales, Ltd. We referred to an axial flow turbo-blower built by the Oerlikon Company with a capacity of 125,000 cubic feet per minute. In fact, the axial flow blower was made by Sulzer Brothers, Ltd., of Winterthur, Switzerland. That blower is driven by an Oerlikon steam turbine. Our apologies are due to Sulzer Brothers, Ltd.

DIESEL-HYDRAULIC LOCOMOTIVES.—It is announced by British Railways that for the construction of three 2000 h.p. diesel-hydraulic locomotives at Swindon Locomotive Works, Western Region, arrangements are being made through the Brush Group for the purchase of three sets of Maybach diesel engines and through J. Stone and Co. (Deptford), Ltd., for the purchase of three sets of Mekydro hydraulic transmissions. The locomotives will be basically similar to those which have been operated with success, and have been adopted as standard by, the German Federal Railways, but with design modifications to meet British requirements. These locomotives will be additional to the 171 main line diesel locomotives already ordered by the British Transport Commission.

ENGINEERING TRAINING PLAN.—The Richardsons Westgarth Group, which includes Richardsons Westgarth (Hartlepool), Ltd., The North-Eastern Marine Engineering Company, Ltd., and George Clarke and North-Eastern Marine (Sunderland), Ltd., has announced the introduction of new recruitment and training schemes to meet the requirements of the wide developments and expansion which the group is undertaking in a wide range of engineering. The technical apprenticeship scheme will recruit boys from secondary grammar and technical schools having the General Certificate of Education at Ordinary level, while the student apprenticeship scheme will accept boys from grammar and public schools who have engineering interests and have attained the Advanced Level standard in the General Certificate of Education.

PHYSICAL STRUCTURE OF CONCRETE.—Mr. T. C. Powers, head of the basic research department of the Portland Cement Association of America, is visiting this country in March this year, when he will give a lecture on the "Physical Structure and Engineering Properties of Concrete." The physical structure of concrete with particular reference to the colloidal nature of the hardened cement paste, the way in which the structure of the paste is built up during hardening, the way in which it takes up and loses water and the way the density, strength, permeability, shrinkage and behaviour under freezing conditions of concrete is related to the structure of the paste, will be discussed. The lecture is to be given at the Institution of Civil Engineers, Great George Street, London, S.W.1, at 6 p.m., on Thursday, March 1st. Tickets may be obtained from the Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1.

NATIONAL DIPLOMA IN AGRICULTURAL ENGINEERING.—The council of the Institution of British Agricultural Engineers is again able to offer at least two scholarships for award to candidates who are eligible for entry to the course of study leading to the final examination in 1957 for the National Diploma in Agricultural Engineering. The Farm Mechanisation scholarship, of the value of £100, is offered for the fifth consecutive year, and The Dunlop Rubber Company, Ltd., is repeating its offer of £250 for award, primarily as a scholarship for the benefit of a degree holder who wishes to obtain the N.D.Agr.E., as a post-graduate specialist qualification. The conditions of award may be obtained from the secretary of the Institution of British Agricultural Engineers, 6, Buckingham Gate, London, S.W.1, the closing date for receiving completed applications being May 1, 1956; preliminary inquiries should be made immediately. The N.D.Agr.E. final examination in 1956 will be held at the examination centre at the Essex Institute of Agriculture, Writtle, Chelmsford, from Tuesday to Friday, July 24th to 27th, inclusive, the oral examinations following on Monday and Tuesday, July 30th and 31st. Applications for entry must be made on the appropriate forms, obtainable from the secretary of the Institution. The closing date for receiving applications is April 1, 1956.

VEHICLE TESTING.—The results of examinations carried out at the Ministry of Transport and Civil Aviation's Vehicle Testing Station at Hendon last year show a very heavy incidence of "major" faults: five out of every six vehicles had faults which, in the opinion of the inspectors, should be put right before the vehicles could be considered fully roadworthy. The 5990 private cars were roughly 1000 over ten years old, 3000 made in 1945–53, and 2000 post-1953. For these groups percentages with major faults were 97, 87 and 77; however, 80 per cent of the cars were considered to have wrongly aimed headlights. One car in every four had faulty steering, mainly due to excessive free play. Brake troubles were equally prevalent, but tyres required attention in only 368 cases. A sample of 261 motor-cycles showed a much lower defect rate of 44 per cent; 142 light goods vehicles also had 80 per cent incidence of faulty headlights, and an overall defect rate of 83 per cent.

BULK TRANSPORT OF LIME.—The Lime Division of Imperial Chemical Industries, Ltd., at Buxton, is now delivering hydrated lime in bulk to customers. The lime is an extremely fine powder, and suppression of dust is one of the less obvious advantages of avoiding handling in paper bags. A 24-ton gross A.E.C. "Mammoth Major" has been fitted by the Duramin Engineering Company, Ltd., with a body essentially similar to that described on June 18, 1954, page 901, the extensive use of aluminium alloys allowing a disposable load of over 14 tons. The capacity of the body is over 1000 cubic feet and a 250 cubic feet per minute Roots two-stage blower will empty the lime into an elevated bunker in about forty-five minutes: a 20 lb per square inch gauge output pressure allows delivery up to a maximum height of 90ft. For gravity discharge only the single-stage 5 lb per square inch blower energising the conveyors is used.

INSTITUTE OF MARINE ENGINEERS.—On Tuesday, January 24th, A. G. Arnold read his paper, "Some Experiences in Vessels Equipped with Two-Stroke Cycle, Harland and Wolff Opposed-Piston Diesel Engines Using Boiler Oil," before the Institute of Marine Engineers. The paper describes the experiences of nine vessels, totalling seventy-five voyages, propelled by this design of engine. Particular reference is made to cylinder wear, as related to the form of fuel injection and to chrome hardening, and also to exhaust piston yokes, main pistons, exhaust pistons, piston crowns and rings. Other items discussed are engine output, scavenge belts and scavenge belt fires, lubricating oil consumption and the electrical installation. The level of maintenance charges is indicated, and a statement is made that boiler oil having a sulphur content up to 4 per cent had been burnt satisfactorily. A description is given of the maiden voyage of "Demodocus," fitted with a two-stroke, opposed-piston, supercharged engine having exhaust gas-turbine-driven blowers and the Archaouloff system of fuel injection. Economies effected by supercharging are mentioned and details given of a gas-turbine-driven emergency generator.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—A paper entitled "Nuclear Reactors for the Generation of Power" was given by C. E. Iliffe, M.A., before the North-East Coast Institution of Engineers and Shipbuilders on Friday, January 27th. The paper deals with the heterogeneous thermal neutron reactors, since it is to these that power generation in the immediate future is considered likely to be confined. Possible combinations of moderator and coolant are reviewed, impractical ones eliminated and further consideration is given to those that remain. They are the heavy-water reactor and light-water reactor, both of the boiling or pressurised design, the water- and gas-cooled graphite moderated reactors and the sodium-graphite reactor. Examples of each type are described and advantages discussed. The thermodynamic aspects of the conversion of the heat liberated are examined and consideration is given to the factors governing the upper temperature at which heat is transferred, while a comparison is made of certain steam cycles. The economics of nuclear power as affecting the United States and Great Britain are reviewed and an analysis is made of costs based upon certain agreed assumptions.

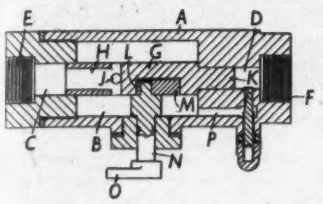
British Patent Specifications

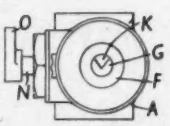
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgement is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgement, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

VALVES

742,080. May 11, 1953.—LIQUID FUEL CONTROL VALVE, Nu-Way Heating Plants, Ltd., Vines Lane, Droitwich, (*Inventor: Willem Jan Nienhuis.*)

The invention relates to a valve for controlling the supply of liquid fuel to an industrial furnace or boiler. Referring to the drawing, a body *A* has within it a cylindrical chamber *B*. At the opposite ends of the chamber are a pair of coaxial bores *C* and D, which respectively communicate with a fuel inlet *E* at one end and an outlet *F* at the other end, the bore leading to the outlet being of smaller diameter than the bore at the inlet end. Within the body part is a slidable





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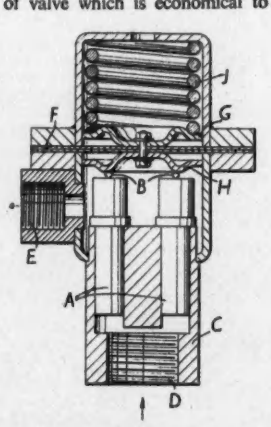
closure member *G*, the two ends of which are slidable in the bores. In the end of the closure member which occupies the inlet bore *C* is an axial passage *H* terminating in radial ports *J* through which liquid fuel can pass to the chamber *B* in the body. The part of the closure member which occupies the outlet bore has formed in it a longitudinal groove *K* of vee or other section of gradually increasing depth, so that when the member is in one of its end positions fuel can pass at the maximum rate to the outlet, and when in the other end position the flow is interrupted, intermediate rates of flow being obtained by moving the closure member to appropriate positions. For actuating the closure member, there is formed in one side of the member a recess *L* which is occupied by a rotatable eccentric *M* secured to one end of a spindle *N* attached to an actuating lever *O*. The lever is automatically operable by a thermostat, thermocouple or pyrometer responsive to temperature. *P* is a by-pass passage between the chamber *B* and the outlet bore *D*, which, as shown, is controlled by an adjustable plug having a groove of gradually increasing depth and which is effective for idling conditions.—*December* 21, 1955.

742,027. August 22, 1953.—PRESSURE-REDUCING VALVES, The Hymatic Engineering Company, Ltd., Glover Street, Redditch, Worcestershire. (*Inventor: Frank Geoffrey Tunnell.*)

The invention relates to pressure-reducing valves and has for its object to provide an improved construction of valve which is economical to produce



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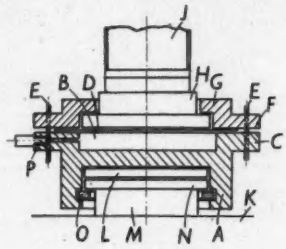
and has a large throughput capacity. As shown in the drawing, a series of valve units *A*, each of which has the end *B* of the valve spindle projecting from its upper end, are located in holes in the valve body *C*, the fluid inlet to which is at *D* and the outlet at *E*. A flexible diaphragm *F* is supported and held between parts of the valve body. Rings *G* and *H* secured to the opposite sides of the diaphragm serve to receive the end of a coil spring *J* and to engage the valve spindles *B* respectively. The underside of the diaphragm is exposed to the outlet fluid pressure and the upper side of the diaphragm is exposed to atmospheric pressure. If the outlet pressure falls below an amount determined by the loading of the diaphragm by the spring *J*, the valve spindles *B* are depressed to increase the valve throughway openings. If the outlet pressure rises unduly, the diaphragm *F* is raised and the valves allowed to close more or less to restrict the fluid flow or to stop it. The valve units *A* are readily placed in and removed from position. By employing a number of valves and disposing them for operation by a common diaphragm, an inexpensive construction of pressure-reducing valve having a large throughput capacity is provided.—*December* 14, 1955.

SAFETY DEVICES

742,380. December 10, 1953.—SAFETY BOXES FOR MACHINES SUBJECT TO STRESS, Dalmine S.p.A., Dalmine (Bergamo), Italy.

The invention has for its object to provide a safety box for machines subject to considerable stresses, such as rolling mills, tube mills, calenders, presses and machines in which considerable pressures are exerted on material undergoing deformation. As



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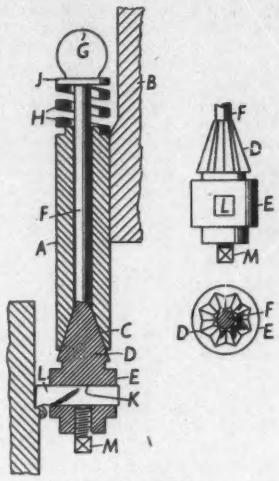
shown in the drawing, *A* is a substantially cylindrical body having a cavity underneath and an upper chamber *B* surrounded by a flange *C*. Upon the flange rests the peripheral portion of the membrane *D*, which completely covers the chamber and is held in position by means of bolts *E* which secure the flange *C* to a counterflange *F* of a stepped ring *G*, thus providing a hermetic sealing for the chamber *B*. The stepped ring *G* houses a pressure element *H*, which is normally supported by membrane *D*, and through which the load is transmitted from member *J*, such as the pressure screw of a rolling mill. The body *A* may rest directly upon a member *K* to which the load is to be applied, as, for example, the roller carrying member of a rolling mill. As shown in the drawing, however, there is provided an indirect rest for the body *A* through a resilient disc *L*, which is supported by the stepped cylinder *M*, the flange *N* of which abuts the split resilient ring *O* housed in a recess in the cavity in body *A*, the whole assembly being supported by member *K* of the machine. The wall of body *A* is provided with a fitting *P* for supplying liquid under pressure into the chamber *B*, and in order to adapt the safety box to the different load values to be transmitted, it is sufficient to vary the pressure of the liquid introduced into the chamber *B*.—*December* 21, 1955.

MACHINE TOOLS

742,266. February 19, 1953.—MEANS FOR SUPPORTING TOOLS OR TOOL HOLDERS IN SLOTTING MACHINES, Norman Gale, 2, Victoria Road, Thornaby-on-Tees, Yorkshire.

The invention relates to means for supporting tool holders or tools in slotting and similar machines so that the holder or tool is rigidly supported during the operative stroke and yieldingly supported during the return stroke. Referring to the drawing, a tubular shank *A* is fixed to the working head *B* of the reciprocating machine and has a socket *C* at its lower end to receive a correspondingly shaped portion *D* of a tool holder *E*, which is provided with a stem *F* extending through the shank and fitted at its upper end with a knob *G*, a spring *H* being interposed between a flange *J* on the knob and the adjacent end of the shank *A*. The tool holder *D* has a horizontal slot *K* to receive a tool *L* which is secured in position by a screw *M*. The socket *C* of the shank *A* is of recessed pyrimidal section, the portion *E* of the tool holder which engages it is shaped to suit. The pyramid may, as shown, be of regular octagonal form, each side having an angular recess providing eight radial positions for the tool *L* in any one of which the tool holder *E* can be readily engaged by depressing the knob *G* of the stem *F* against the resistance of the spring a sufficient distance to disengage the pyramid *D* from the socket *C* and permit the tool holder to be rotated from one position to another by means of the knob. The spring *H* and socket *C* coact to present the tool *L* to the work in such a manner that the tool point is held rigidly up to the work during the cutting stroke of the machine and is allowed to trail lightly over the work on the return or idle stroke. The cutting stroke tends to push the tool holder *E* into the socket *C* while, during the return stroke, the pressure is



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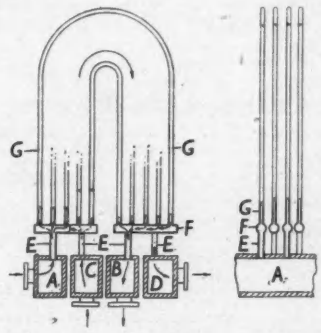
relieved and the tendency is to pull the tool holder partially out of the socket. If desired, or where the work does not permit the use of a tool holder such as *E*, the recessed pyramidal portion *D*, the stem *F* and the knob *G* may be in one with the tool *L*.—*December* 21, 1955.

STEAM GENERATORS

743,077. March 19, 1953.—TUBULAR STEAM HEATING ELEMENTS, Foster Wheeler, Ltd., Foster Wheeler House, 3, Ixworth Place, London, S.W.3. (*Inventor: Leonard James Culver.*)

The invention relates to tubular steam heater elements which are particularly suitable for use as steam reheaters in marine boilers. An example of a heating element in accordance with the invention is shown diagrammatically in the drawing. The element comprises two pairs of inlet and outlet headers lying side by side, the headers *A* and *B*



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being assumed to be the inlet and outlet headers for the steam to be reheated for use in the low pressure port turbine of a marine boiler installation and the headers *C* and *D* the corresponding headers for the low pressure starboard turbine. Each header has short tubes *E* rising from it, the tubes in each header being in line with each other and the tubes of the two inlet headers and those of the two outlet headers being staggered. Each tube *E* leads to a cross tube *F* and the two corresponding cross tubes associated with a pair of inlet and outlet headers *A* and *B* or *C* and *D* are connected together by a number of "U"-tubes *G*. Each cross tube *F* overlies a pair of inlet or outlet headers. Thus, in the direction of the length of the headers there are a number of identical closely spaced groups of "U"-tubes connected alternately to the port and to the starboard headers. If, therefore, the element is arranged in a gas stream in a boiler so that the gas flows between the groups transversely to the length of the headers, the steam for the port turbine and that for the starboard turbine will be heated under substantially identical conditions. Any deterioration of the tubes which can affect the heat transfer, such as that caused by soot or slag deposits, will occur equally in the two sets of tubes and, therefore, no substantial variation will occur in the course of time.—*January* 11, 1956.

Launches and Trial Trips

OTI, cargo liner ; built at Belfast by Harland and Wolff, Ltd., for Elder Dempster Lines, Ltd.; length between perpendiculars 425ft, breadth moulded 62ft, depth moulded to shelter deck 34ft, gross tonnage 5900 ; four main cargo holds, sixteen derricks, one 30-ton derrick and one 80-ton derrick, electric deck machinery, four 125kW diesel-driven generators ; Harland and Wolff two-stroke, single-acting opposed piston oil engine, five cylinders 620mm diameter by 1870mm combined stroke, 115 r.p.m. Launch, December 15th.

RUTH LAKE, ore carrier ; built at the Wallsend yard of Swan, Hunter and Wigham Richardson, Ltd., for the Iron Ore Transport Company, Ltd., Canada ; length overall 661ft 7½in, length between perpendiculars 630ft, breadth moulded 87ft, depth moulded 45ft 6in, draught 34ft 0½in, deadweight 31,000 tons, service speed 14¾ knots ; three ore holds, two arranged to carry oil ; one cargo oil pump room, four turbo horizontal centrifugal pumps, each rated at 4500 United States gallons per minute at 125 lb per square inch, four stripping pumps, steam deck machinery ; two 500kW geared turbo-alternators, one 150kW diesel-driven alternator ; machinery supplied by the Wallsend Slipway and Engineering Company, Ltd., one set of double reduction geared compound turbines, service power 12,500 s.h.p. at 105 propeller r.p.m., two Foster Wheeler boilers supply steam at 690 lb per square inch and 850 deg. Fah. Launch, December 15th.

SAMUEL UGELSTAD, oil tanker ; built by the Furness Shipbuilding Company, Ltd., for S. Ugelstads Rederi A/S, Norway ; length between perpendiculars 630ft, breadth moulded 87ft, depth moulded 45ft 6in, deadweight 32,000 tons on 34ft 2in summer draught, trial speed 15½ knots ; thirty cargo oil compartments, one main cargo pump room, four 3320 gallons per minute centrifugal turbine-driven pumps, four 150 tons per hour stripping pumps ; two 500kW turbo-alternators, one 100kW diesel-driven alternator ; machinery built by Richardsons, Westgarth and Co., Ltd., one set of double reduction geared turbines, maximum power 13,750 s.h.p. at 108 propeller r.p.m., normal power 12,500 s.h.p. at 105 propeller r.p.m., steam supplied at 600 lb per square inch and 850 deg. Fah. by two Foster Wheeler boilers. Launch, December 15th.

REAVELEY, open shelter deck cargo ship ; built at the Neptune Works of Swan, Hunter and Wigham Richardson, Ltd.; length between perpendiculars 435ft, breadth moulded 60ft, depth moulded to shelter deck 39ft ; five cargo holds, one 30-ton, two 10-ton and eight 6-ton derricks, steam deck machinery, two multitubular boilers ; Swan, Hunter-Doxford diaphragm oil engine, arranged to burn boiler fuel, four cylinders 670mm diameter by 2320mm combined stroke, 4400 b.h.p. at 115 r.p.m. Trial, December 29th.

Catalogues and Brochures

DAVIDSON AND CO., Ltd., Sirocco Engineering Works, Belfast, Northern Ireland.—Leaflet dealing with contra-rotating, axial-flow fans for auxiliary mine ventilation, and a catalogue giving particulars of various designs of "Sirocco" centrifugal fans, for use in power stations and boiler-houses.

HERCULES POWDER COMPANY, Ltd., 140, Park Lane, London, W.1.—Brochure giving particulars of "Akulon" nylon rod material, including factors affecting dimensional stability, notes upon machining, milling, sawing, turning, drilling and polishing, and a list of the rod diameters available.

HENRY WIGGIN AND CO., Ltd., Thames House, Millbank, London, S.W.1.—Special issue of "Wiggin Nickel Alloys," devoted to the nickel-copper alloy Monel. The introduction describes the development of Monel and illustrations show some of the many uses of this alloy.

THE EXPANDED METAL COMPANY, Ltd., Burwood House, Caxton Street, Westminster, London, S.W.1.—Booklet entitled "Expanded Metal in Industry," giving its applications ranging from ceiling panels, balustrades and machinery guards to plate racks, lamps and cocktail trays.

THE KINGSTON ENGINEERING COMPANY, Ltd., 44, Tower Hill, London, E.C.3.—Illustrated brochure dealing with screw threads and giving details of thread definitions, square threads, acme threads, buttress threads, extruder screws and special-purpose screw threads.

ALAR, Ltd., Albemarle Street, London, W.1.—Data sheet giving the related specifications, properties and characteristics of the standard aluminium casting alloys used for general engineering purposes. The information is presented in the form of a wall chart.

EVERSHED AND VIGNOLES, Ltd., Acton Lane Works, Chiswick, London, W.4.—Publication No. ED.056. A selection chart giving details of the many different "Megger" insulation testers.

THE MORGAN REFRACTORIES, Ltd., Neston, Wirral, Cheshire.—Technical Sales Bulletin No. 52, dealing with the "Morgan Law Heat-Storage Insulating Refractories," M.I.28, M.I.26, M.I.23.

INDUSTRIAL TRUCK MANUFACTURERS' ASSOCIATION, 94-98, Petty France, London, S.W.1.—Publication entitled "Operators' Safety Code for Industrial Power Trucks," price 1s. post free.

HIGH DUTY ALLOYS, Ltd., Slough, Bucks.—Illustrated booklet entitled "Aircraft Castings in Hiduminium and Magnuminium," dealing with high-strength alloys at elevated temperatures.

LONDEX, Ltd., Anerley Works, London, S.E.20.—Lists Nos. 142/A and 170, dealing with single-hole fixing signal lamp fitting, type 960, and a synchronous process timer, type RFT.

THERMALITE, Ltd., Shepherds House Lane, Earley, Reading.—Illustrated booklet describing Thermalite, a lightweight structural building material with high thermal insulation value.

GORING KERR, Ltd., Clifton Works, at the rear of 153, High Street, Slough, Bucks.—Leaflet giving details of the "SJ" series of metal detectors used in electronic metal detection.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Feb. 3rd.—LIVERPOOL BRANCH : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, "Instrument Transducers and their Application to Industry," G. R. Polgreen, 7.30 p.m.

Mon., Feb. 6th.—LEEDS BRANCH : Great Northern Hotel, Leeds, "Space Heating," 7.30 p.m.——N.E. LONDON BRANCH : Angel Hotel, Ilford, "Thermoplastic Cables," F. J. Smith, 8 p.m.——SHEFFIELD BRANCH : Royal Victoria Station Hotel, Sheffield, "Gas-Filled Cables," 7.30 p.m.

Tues., Feb. 7th.—S.E. LONDON BRANCH : Congregational Church, Court Road, Eltham, "Stage Lighting," 8 p.m.——S. WALES BRANCH : Angel Hotel, Westgate Street, Cardiff, Talk on "Safety Regulations," 7.30 p.m.——W. LONDON BRANCH : Windsor Castle Hotel, 134, King Street, Hammersmith, "Electrostatic Precipitation," S. Laurie-Walker, 7.30 p.m.——OXFORD, READING AND DISTRICTS BRANCH : University Letters Lecture Theatre, London Road, Reading, "The Industrial Use of Magnetic Power," T. Hawker, 7 p.m.

Wed., Feb. 8th.—BIRMINGHAM BRANCH : Chamber of Commerce, New Street, Birmingham, "Switchgear," 7.15 p.m.——HALIFAX BRANCH : Crown Hotel, Horton Street, Halifax, "Industrial and Commercial Lighting," J. W. Howell, 7.30 p.m.——S.W. LONDON BRANCH : Guild House, 32, Worple Road, Wimbledon, "Specialised Spot Welding," C. G. Aldridge, 8.15 p.m.——YORK BRANCH : The Shambles Cafe, York, "Earth Fault Protection," F. Grant, 7.15 p.m.

Thurs., Feb. 9th.—SOUTHAMPTON BRANCH : Polygon Hotel, Southampton, Technical Films, 8 p.m.

Fri., Feb. 10th.—STOKE AND CREWE BRANCH : North Stafford Hotel, Stoke, "Power System Protection," F. E. Wellman, 8 p.m.

BATTERSEA POLYTECHNIC

Tues., Feb. 7th.—Battersea Polytechnic, London, S.W.11, "Modern Methods of Routine Analysis," P. C. Thornton, 7 p.m.

BRITISH WELDING RESEARCH ASSOCIATION

Tues. and Wed., Feb. 7th and 8th.—Mechanics' Institution, Trinity Square, Nottingham. Tuesday : "Recent Developments in Welding Steel," A. R. Muir, 9.30–11 a.m.; "Effect of Design on Production with references to Fatigue Loading," R. Weck ; 11.30–1 p.m., "Developments in Non-Destructive Testing," H. L. Carson, 2.30–5 p.m. Wednesday : "Processes for Welding Light Alloys," W. G. Hull, 9.30–11 a.m.; "Resistance Welding Ferrous and Non-Ferrous Metals," E. V. Beatson, 11.30–1 p.m.; "What can be done to reduce Fatigue Failure and Brittle Fracture," A. A. Wells, 2.30–3.30 p.m.; "The Problem of Productivity Improvement in Welded Production," A. G. Thompson, 4–5 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Feb. 7th.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, "Electronics in Industry," J. E. Fielden, 7 p.m.

Wed., Feb. 8th.—E. MIDLANDS BRANCH : County Hotel, Theatre Square, Nottingham, Recording of Sir Oliver Lyle's Address, 7 p.m.——WESTERN BRANCH : Grand Hotel, Bristol, "The Factory Act and the Works Engineer," Miss F. E. Messiter, 7.15 p.m.

Thurs., Feb. 9th.—GLASGOW BRANCH : Scottish Building Centre, 425–427, Sauchiehall Street, Glasgow, "Engineering Metals," J. Winning, 7 p.m.

Mon., Feb. 13th.—DUNDEE BRANCH : Mathers Hotel, Dundee, "Lifting Gear," J. W. Steele, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Thurs., Feb. 9th.—LANCASHIRE BRANCH : Midland Hotel, Manchester, "Simple Foundry Expedients Proved Worthwhile in Recent Years," J. E. O. Little, 3 p.m.——LINCOLNSHIRE BRANCH : Technical College, Lincoln, "Jobbing Work in the Foundry," E. Clipson, 7.15 p.m.——BEDS AND HERTS SECTION : K. and L. Steelfounders and Engineers, Ltd., Letchworth, Technical Films, 7.30 p.m.——BURNLEY SECTION : College of Further Education, Sandy Lane, Accrington, "Shell Moulding," 7.30 p.m.

Fri., Feb. 10th.—TEES-SIDE BRANCH : Teesdale Hall, Head, Wrightson and Co., Ltd., Thornaby-on-Tees, "Foundry Problems and Principles," G. J. Rogers, 7.30 p.m.

INSTITUTE OF FUEL

To-day, Feb. 3rd.—S. WALES SECTION : S. Wales Institute of Engineers, Park Place, Cardiff, "Research at the National Coal Board," W. Idris Jones, 6 p.m.

Wed., Feb. 8th.—N.W. SECTION : Engineers' Club, Albert Square, Manchester, "Some Recent Advances in Fuel Research," W. Idris Jones, 2.30 p.m.

Fri., Feb. 10th.—SCOTTISH SECTION : North British Hotel, Edinburgh, "Smokeless-Fuel Production," A. Vaughan Cowell, 7 p.m.

INSTITUTE OF PETROLEUM

Wed., Feb. 8th.—26, Portland Place, London, W.1, "A Legal Department in an Oil Company," F. U. J. O'Brien, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Feb. 7th.—WESTERN CENTRE : Royal Hotel, Bristol, "Petrol Injection," J. N. Morris, 7.30 p.m.

Wed., Feb. 8th.—E. MIDLANDS CENTRE : Mechanics' Institute, Nottingham, "The Operation and Development of Disc Brakes," T. J. Phipps, 7.30 p.m.

Thurs., Feb. 9th.—WESTERN REGION CENTRE : Adelphi Hotel, Lime Street, Liverpool, "Piston Design and Maintenance," I. Howell, 7.30 p.m.

INSTITUTE OF WELDING

Wed., Feb. 8th.—PRESTON BRANCH : Technical College, Corporation Street, Preston, "Some Lesser-Known Uses of the Oxy-Acetylene Flame," D. W. Wright, 7.15 p.m.

Thurs., Feb. 9th.—S. LONDON BRANCH : 2, Savoy Hill, London, W.C.2, "Welding Metallurgy and Electrode Development," J. Mercer, 6.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Feb. 7th.—Geological Society, Burlington House, Piccadilly, London, W.1, "Liquid Atomisation and the Drop Size of Sprays," R. P. Fraser and P. Eisenklam, 5.30 p.m.

Wed., Feb. 8th.—N.W. BRANCH : The University, Leeds, "A Statistical Approach to Catalyst Development," N. L. Franklin, P. H. Pinchbeck and F. Popper, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Feb. 7th.—HYDRAULICS MEETING : Great George Street, Westminster, London, S.W.1, "Some Hydraulic Investigations in Connection with Wadi Tharthar Project, Iraq," A. R. Thomas, 5.30 p.m.——MIDLANDS ASSOCIATION : Mechanics' Institute, Nottingham, "Some Aspects of Prestressed Concrete Bridge Design," A. Goldstein, 6.15 p.m.

Thurs., Feb. 9th.—N.W. ASSOCIATION : Engineers' Club, Albert Square, Manchester, "Some Effects of Mining Subsidence," C. E. Farran, 6.30 p.m.——MIDLANDS ASSOCIATION : James Watt Memorial Institute, Great Charles Street, Birmingham, "The Development of Sewage Treatment in the City of Coventry," Granville Berry and C. R. Deeley, 6 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Feb. 6th.—INFORMAL MEETING : Savoy Place, London, W.C.2, Discussion on "What Should be Our National Fuel Policy," opened by E. F. Schumacher, 5.30 p.m.——S. MIDLAND CENTRE : James Watt Memorial Institute, Great Charles Street, Birmingham, "Electrical and Magnetic Measurements in an Electrical Engineering Factory," D. Edmundson, 6 p.m.

Tues., Feb. 7th.—LONDON GRADUATES' AND STUDENTS' SECTION : Savoy Place, London, W.C.2, "A Survey of the Various Types of Tachogenerators Suitable for Control Applications," L. J. Janes, 6.30 p.m.——N. MIDLAND CENTRE : Central Electricity Authority, 1, Whitehall Road, Leeds, 1, "Measurement as a Factor in Understanding," K. J. R. Wilkinson, 6.30 p.m.

Wed., Feb. 8th.—RADIO AND TELECOMMUNICATIONS SECTION : Savoy Place, London, W.C.2, "Pulse Techniques, with particular reference to Line and Radio Communication," E. M. Deloraine, 5.30 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Wed., Feb. 8th.—Royal Society of Arts, John Adam Street, London, W.C.2, "Isotopes in Industry," J. C. Rockley, 6.45 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Fri., Feb. 10th.—MANCHESTER AND DISTRICT BRANCH : Engineers' Club, Albert Square, Manchester, "Process Control in Industry," J. E. Fielden, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Mon., Feb. 6th.—N.E. SECTION : Neville Hall, Newcastle upon Tyne, "Marine Reduction Gearing," A. W. Davis, 6 p.m.

Wed., Feb. 8th.—N.W. BRANCH : Liverpool Engineering Society's Room, 24, Dale Street, Liverpool, "Marine Reduction Gearing," A. W. Davis, 6 p.m.

Thurs., Feb. 9th.—EASTERN BRANCH : Great White Horse Hotel, Ipswich, "Fuel Control and Burning in Aero-Gas-Turbine Engines," E. A. Watson, 7.30 p.m.——SCOTTISH BRANCH : Royal Technical College, George Street, Glasgow, "Marine Reduction Gearing," A. W. Davis, 7.30 p.m.

Fri., Feb. 10th.—SCOTTISH BRANCH : Robert Gordon's College, Aberdeen, "Marine Reduction Gearing," A. W. Davis, 7.30 p.m.——SOUTHERN BRANCH : Municipal College, Bournemouth, "Control Valves for Direct Hydraulic Presses," F. H. Towler, 7 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Feb. 6th.—HALIFAX SECTION : White Swan Hotel, Halifax, "Computer Controlled Machine Tools," H. Ogden, 7.15 p.m.

Tues., Feb. 7th.—PETERBOROUGH SECTION : White Lion Hotel, Church Street, Peterborough, "The Use of Electronics in Engineering," J. A. Stokes and N. B. Milne, 7.30 p.m.

Wed., Feb. 8th.—NORWICH SECTION : Assembly House, Theatre Street, Norwich, "Material Handling for Batch Production," A. Harvey, 7.30 p.m.——COVENTRY SECTION : Church House, Rugby, "The Effect of Operative Conditions on Designing and Constructing of Diesel-Electric Locomotives," G. G. Kibblewhite, 7 p.m.——LIVERPOOL SECTION : Exchange Hotel, Liverpool, "Non-Destructive Testing," J. Johnson, 7.30 p.m.——PRESTON SECTION : Crown Hotel, Market Place, Blackburn, "The Application of Accurate Measurement to Engineering Production," J. Loxham, 7.15 p.m.——NOTTINGHAM SECTION : Victoria Station Hotel, Nottingham, "The High Cost of Low Overheads," C. H. Starr, 7 p.m.——SCOTTISH SECTION : New Imperial Hotel, 15, Tally Street, Dundee, "Electronic Control of Machine Tools," E. Heys, 7.30 p.m.

Thurs., Feb. 9th.—LEICESTER SECTION : Bell Hotel, Leicester, Annual General Meeting, Film, "Induction Heating," 7 p.m.——ROCHESTER SECTION : Sun Hotel, Chatham, "The Work of H.M. Inspectors of Factories," V. B. Jones, 7.30 p.m.

Fri., Feb. 10th.—EASTERN COUNTIES SECTION : Diocesan Hall, Tower Street, Ipswich, "Drop Forging," G. Kemp, 7.30 p.m.——W. WALES SECTION : Central Library, Alexandra Road, Swansea, "Automation for Production," F. Garner, 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Feb. 3rd.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Film Evening, 7 p.m.

Fri., Feb. 10th.—ORDINARY MEETING : Pepys House, 14, Rochester Row, London, S.W.1, "A Production Control System Incorporating an Electronic Computer," W. J. Kease, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Feb. 3rd.—Engineers' Club, Albert Square, Manchester, "Pneumatic Handling of Powdered Materials in the Food Industries," R. W. Allen and J. W. Farrand, 6.45 p.m.

NEWCOMEN SOCIETY

Wed., Feb. 8th.—Science Museum, South Kensington, London, S.W.7, "The Manbys and the Industrial Revolution in France, 1819–1884," W. H. Chaloner and W. O. Henderson, 5.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Feb. 10th.—Mining Institute, Newcastle upon Tyne, "Bearings for Marine Geared Turbines," A. D. Newman, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Feb. 7th.—MIDLAND COUNTIES BRANCH : Midland Institute, Paradise Street, Birmingham, "Continental Concrete Roads," D. R. Sharp, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Feb. 9th.—SECTION LECTURE : Library, 4, Hamilton Place, London, W.1, "Propellers for Military and Civil Aircraft," L. G. Fairhurst, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Feb. 6th.—ORDINARY GENERAL MEETING : 12, Great George Street, Westminster, London, S.W.1, Discussion on "Farm Rents," R. C. Walmsley, 5 p.m.

SOCIETY OF ENGINEERS

Mon., Feb. 6th.—Geological Society, Burlington House, Piccadilly, London, W.1, Presidential Address, H. F. Jackson, 5.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Thurs., Feb. 9th.—Manson House, 26, Portland Place, London, W.1, "The Scope for Feedback Control and Automatic Calculation in Industrial Mechanisation," A. Tustin, 6.30 p.m.